Endangered Species Act - Section 7
Consultation

SUPPLEMENTAL BIOLOGICAL OPINION

Operation of the Federal Columbia River Power System
Including the Smolt Monitoring Program and the Juvenile Fish Transportation Program:
A Supplement to the Biological Opinion Signed on March 2, 1995,
For the Same Projects

Agencies: U.S. Army Corps of Engineers
Bonneville Power Administration
Bureau of Reclamation
National Marine Fisheries Service

Consultation Conducted by: National Marine Fisheries Service,
Northwest Region

Date Issued: May 14, 1998

TABLE OF CONTENTS

I. OBJECTIVES

This is an interagency consultation pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) and implementing regulations found at 50 CFR Part 402. The federal agencies that operate or market power from the Federal Columbia River Power System (FCRPS), namely the Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (Corps), and the U.S. Bureau of Reclamation (BOR) (collectively "the Action Agencies"), previously consulted with the National Marine Fisheries Service (NMFS) concerning the effects of the FCRPS on three listed species of Snake River salmon. The NMFS concluded that consultation with its biological opinion and reasonable and prudent alternative (RPA) entitled "Reinitiation of Consultation on the 1994-1998 Operation of the FCRPS and Juvenile Transportation Program in 1995 and Future Years" issued on March 2, 1995 (hereafter referred to as the 1995 FCRPS Biological Opinion and the 1995 RPA). The Action Agencies have reinitiated that consultation to consider the effects of the FCRPS on recently listed species of anadromous fish: Snake River, Upper Columbia River, and Lower Columbia River steelhead (Oncorhynchus mykiss). This document constitutes NMFS' Supplemental FCRPS Biological Opinion concerning these newly listed species. The objective of this consultation is to determine whether the operation of the FCRPS, as proposed by the Action Agencies and described in Section III (below), is likely to jeopardize the continued existence of the Snake River steelhead (listed as threatened on August 18, 1997 [62 FR 43937]), Upper Columbia River steelhead (listed as endangered on August 18, 1997 [62 FR 42937]), or Lower Columbia River steelhead (listed as threatened on March 19, 1998 [63 FR 13347]).[1]

This Biological Opinion supplements the 1995 FCRPS Biological Opinion. The 1995 opinion, including its RPA and incidental take statement, shall continue in full effect except to the extent that the Action Agencies' proposed action, as described in Section III (below) or this Supplemental FCRPS Biological Opinion, including its incidental take statement, changes particular measures in the 1995 opinion or establishes additional measures.

An additional objective of this Supplemental Biological Opinion is to determine whether the modification of the Section 10 permits for the juvenile transportation program and the smolt monitoring program as described in Section III.B is likely to jeopardize the listed steelhead species described in the previous paragraph. A related objective is to determine whether extension of the same Section 10 permits through December 31, 1999, is likely to jeopardize listed Snake River spring/summer chinook salmon (Oncorhynchus tshawytscha), Snake River fall chinook salmon (O. tshawytscha), or Snake River sockeye salmon (O. nerka).

[1] The NMFS has not designated critical habitat for any of these three species. Therefore, in this Supplemental FCRPS Biological Opinion, we consider the effects of the proposed action on steelhead habitat within the context of our jeopardy decision.

During this consultation, NMFS proposed additional salmonid stocks for ESA listing (Upper Columbia River Spring-Run Chinook, Middle Columbia River Steelhead, Lower Columbia River Chinook, Columbia River Chum Salmon [O. gorbuscha], Upper Willamette River Steelhead, and Upper Willamette River Chinook). The U.S. Fish and Wildlife Service (USFWS) has also proposed to list Columbia Basin bull trout (Salvelinus confluentus). The Action Agencies, USFWS and NMFS will continue to consider and evaluate potential effects to these additional species.

In the course of this consultation, NMFS has considered the current implementation of the 1995 RPA for listed Snake River chinook and sockeye. This is a periodic evaluation that NMFS and the Action Agencies have conducted according to the "Framework" procedure called for by 1995 RPA Measure 26 and as described in the letter of November 14, 1996, from NMFS to the Corps. In the Framework analysis, NMFS determines whether implementation decisions made during the adaptive management process necessitate further consultation concerning these Snake River species. The current (1998) Framework analysis is presented in Section VII of this Supplemental FCRPS Biological Opinion and, as described in the preface to Section III (Proposed Action), in that section as well.

II. BACKGROUND

A. Events Leading to this Opinion

On March 2, 1995, NMFS issued the Endangered Species Act - Section 7 Consultation Biological Opinion titled "Reinitiation of Consultation on the 1995-1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years" (hereafter referred to as the 1995 FCRPS Biological Opinion). In that opinion, NMFS determined that the proposed action, described in the 1994-1998 FCRPS Biological Opinion (March 16, 1994), was likely to jeopardize the continued existence of listed spring/summer chinook salmon. The 1995 FCRPS Biological Opinion set out a reasonable and prudent alternative (RPA) to the proposed action which was adopted by the Action Agencies in their Records of Decision. Subsequently, in the course of adaptive management, the RPA was modified, as described in a November 14, 1996, letter from W. Stelle (NMFS) to B. Bohn (Corps).

The NMFS announced the listings of the Snake River and Upper Columbia River steelhead ESUs on August 18, 1998 (see Section I). In a letter to W. Stelle (NMFS) on the same date, J. Velehradsky (Corps) requested a species list. Stelle provided the list to J. Velehradsky, R. Hardy (BPA) and J. Keys (BOR) (letter dated September 3, 1997), requesting all three Action Agencies to participate in discussions regarding the effects of the FCRPS on listed steelhead.

Informal discussions among NMFS, the Action Agencies and the fish and wildlife managers commenced in the fall in the Regional Forum and at the Columbia Basin Fish and Wildlife Authority. Most of the discussion focused on potential flow, spill, and transport operations.

The Action Agencies transmitted their final "Biological Assessment for 1998 and Future Operation of the Federal Columbia River Power System, Upper Columbia and Lower Snake River Steelhead" (hereafter referred to as the Action Agencies' Biological Assessment) to NMFS on January 21, 1998. This included a request for conferencing on Lower Columbia River steelhead, which were proposed for listing at that time. On March 13, 1998, this ESU was listed as "threatened" and this species was included in the consultation. The Action Agencies clarified their proposed action in a letter from D. Geiger (Corps) to B. Brown dated February 12, 1998.

The NMFS engaged in consultation discussions with the Action Agencies, in coordination with USFWS, and transmitted a draft Supplemental Biological Opinion to these agencies on March 17, 1998 (letter from B. Brown [NMFS] to D. Arndt [Corps], R. McKown [BOR], D. Daley [BPA], and F. Olney [USFWS]). Based on further consultation with the Action Agencies, and additional meetings with the salmon managers, NMFS produced a revised draft for review and comment by the comanagers on March 19, 1998. Comments were accepted during the two week period ending April 3, 1998. Many comments were also received from the public and non-governmental organizations. All comments received were considered in the development of this final biological opinion. The NMFS transmitted the final Proposed Action (Chapter III of this Supplemental FCRPS Biological Opinion) to the Action Agencies on May 11, 1998, with a letter requesting that the Action Agencies concur with the action and measures described. The NMFS based this request on its determination that actions consistent with these measures, which supplement the RPA in the 1995 FCRPS Biological Opinion, will satisfy the requirements of the Endangered Species Act concerning listed Snake and Columbia River steelhead. The Action Agencies, in a letter dated May 13, 1998, agreed to supplement their proposed action with these additional measures in response to NMFS' recommendation.

Also beginning February 4, 1998, NMFS held a series of meetings with the nonfederal fish and wildlife managers. These were coordinated through the Implementation Team and through the Columbia Basin Fish and Wildlife Authority (CBFWA) and included affected agencies and tribes who do not participate in the Regional Forum. The NMFS also briefed the Northwest Power Planning Council and engaged in subsequent discussions with Council members. During those meetings, the nonfederal fish and wildlife managers and others commented on the technical elements of the proposed action. Beginning on February 27, 1998, open meetings were jointly held with both the Action Agencies and fish and wildlife managers.

The NMFS invited consultation with the 13 sovereign tribes of the Columbia basin in a letter faxed and mailed from W. Stelle to each tribal chairman dated February 18, 1998. Copies of this letter were also transmitted to the Columbia River Intertribal Fish Commission, the Upper Columbia River United Tribes, the Columbia Basin Fish and Wildlife Authority, and the Northwest Power Planning Council. In this letter, NMFS invited each tribe to participate in the Endangered Species Act Section 7 consultation with the Action Agencies to develop the Supplemental FCRPS Biological Opinion for steelhead. The letter recognized that tribal rights and tribal trust resources could be affected by NMFS' findings and recommendations and actively solicited tribal expertise in developing analyses of effects, biological requirements, and mitigation strategies for listed steelhead. The NMFS also offered to meet individually with the tribes on a government-to-government basis. In response to this invitation, NMFS met with representatives of the Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakama Indian Nation. Staff of the Columbia River Intertribal Fish Commission also participated. A technical-level meeting took place at CRITFC's office in Portland, Oregon, on February 20, 1998. A policy-level meeting took place in the same location on March 27, 1998.

Comments received during the public comment period were considered by NMFS and discussed with the Action Agencies during the period April 6 through 10, 1998. Many of the substantive comments were addressed in the final draft and are included in this final Supplemental Biological Opinion.

III. PROPOSED ACTION

Some elements of the proposed action, as described in the following sections, principally affect listed Snake River spring/summer and fall chinook or sockeye salmon rather than Snake, Upper Columbia, or Lower Columbia River steelhead. To that extent, the description of the Action Agencies' proposed action includes elements that are considered in the Framework coordination that was established by the 1995 FCRPS Biological Opinion. The Framework process and NMFS conclusions relative to this Supplemental FCRPS Biological Opinion are described in Section VII.

A. Operation of the FCRPS by the Action Agencies (Corps, BPA, and BOR)

The primary action proposed in the Action Agencies' Biological Assessment is implementation of the reasonable and prudent alternative (RPA) of the 1995 FCRPS Biological Opinion, as adopted by the Action Agencies in their Records of Decision and as subsequently modified through the November 14, 1996, Framework letter from W. Stelle (NMFS) to B. Bohn (Corps).

The Biological Assessment proposed additional actions and modifications of certain measures in the RPA in the 1995 FCRPS Biological Opinion for the purpose of maximizing transportation of listed Snake River steelhead and Upper Columbia River steelhead from collector projects (February 12, 1998, letter from D. Geiger [Corps] to B. Brown [NMFS]). These measures included curtailing voluntary spill at collector projects, transporting juveniles from McNary Dam during the spring migration, and allowing additional flexibility in reservoir elevations to control involuntary spill at collector projects.

During the consultation, the Independent Scientific Advisory Board (ISAB) released a review of scientific issues related to transportation, which included recommendations for the 1998 juvenile transportation program (ISAB 1998). The review stated, "The present mixed-stock truck and barge transportation system probably would improve survival for some affected populations, given the same inriver survival levels present during the NMFS studies. However, the effect of transportation on any particular population is unknown..." and "...the combined effects of collection and transportation may decrease survival for some populations, life history types and species." The conclusions and recommendations of the ISAB included: (1) employ a "spread the risk" approach to transportation; (2) eliminate the use of trucks in the transportation program; (3) develop management actions for protecting salmon and steelhead at the population-specific level to the maximum extent possible; and (4) operate the hydrosystem in a manner that maximizes the survival of inriver migrants.

Based on the ISAB's recommendations, NMFS determined that it was not appropriate to maximize transportation at the four FCRPS collector projects, as proposed in the Biological Assessment. The NMFS requested that the Action Agencies reconsider their proposal to eliminate voluntary spill at the Snake River collector projects and to allow greater fluctuations in reservoir elevations to reduce involuntary spill.

Regarding transportation from McNary Dam, NMFS and the Action Agencies agreed that a proportion of the Upper Columbia steelhead outmigration should be transported from McNary Dam during the period of this Supplemental FCRPS Biological Opinion in order to "spread the risk" for this ESU. However, NMFS identified results of recent PIT-tag analyses which suggest that there may be a problem with collection and transportation of spring migrants from that project. Until this issue is resolved through further research, spring transportation of the run-at-large at McNary will not occur.

An additional response to the ISAB report was to specify measures that would lead to a reduction in the proportion of the run that is transported from Snake River projects by truck during 1998. The Action Agencies have proposed additional research to move toward an understanding of the effects of transportation on individual stocks.

The final elements of the Action Agencies' proposed action, which either supplement or modify the Reasonable and Prudent Alternative described in the 1995 FCRPS Biological Opinion, are as follows:

1. Spring Flow Objectives

Spring Flow Objective for the Mid-Columbia River

Based on the best available information, NMFS believes that low river flows result in reduced survival of listed juvenile Upper Columbia River steelhead[2] and that establishing flow objectives will help increase juvenile survivals; increased juvenile survivals will potentially lead to increased adult returns in the long term. Although there have been no studies of juvenile survival over a range of flows specific to listed steelhead in the mid-Columbia reach, data pertaining to other relevant stocks in the Snake River support the designation of a mid-Columbia flow objective for steelhead of 135 kcfs at Priest Rapids. This flow objective and the supporting biological rationale are further described in Appendix A.

The NMFS defines a seasonal flow objective as a guide to the inseason process and as a mechanism for comparing various operational scenarios (e.g., one scenario might give a 70% chance of meeting flow objectives while another gives a 50% chance). The 1995 FCRPS Biological Opinion and this Supplemental FCRPS Biological Opinion give general direction to the inseason management process on the factors to take into account in making decisions about inseason operations that will result in levels of flow expected to provide the greatest survival benefits to listed fish. The biological opinions do not require seasonal average flow objectives to be met on a weekly basis, nor do they suggest that flow augmentation can be stopped or diminished once a seasonal average has been met. Rather, the requirement is to operate as

[2] Throughout this Supplemental FCRPS Biological Opinion, the nomenclature Upper Columbia River steelhead refers to the steelhead ESU. The nomenclature "mid-Columbia River" designates the reach of the mainstem Columbia River from below Chief Joseph Dam to the head of the McNary pool.

described in the 1995 FCRPS Biological Opinion and in the various additional measures defined below. These operations are intended to benefit one or more listed species. For example, refilling reservoirs by the end of June, together with end-of-summer draft points, provides water to augment flows for summer migrating fish. Operating to the flood control upper-rule curve on April 10 of each year provides water to augment flows for spring migrating fish. The goal of the inseason management process is then to use the water available from runoff and from these storage reservoir operations to augment flows as necessary to improve the survival of listed fish throughout the season. In the event that operations of the FCRPS are inconsistent with these measures, the Action Agencies will seek and consider additional measures to address potential adverse effects. Where possible, additional measures will provide survival benefits in-place, in-kind, and in a timely manner. As appropriate, the Action Agencies will consult with NMFS through the 1995 RPA Measure 26 Framework process, or a similar process, to reflect the modification or to consider other reasonable measures for the species which the operation was intended to benefit.

The BPA performed 50-year hydroregulation modeling of the measures in the 1995 FCRPS Biological Opinion, as supplemented by this Biological Opinion. The evaluation included both the effect of the additional measures required by this Supplemental FCRPS Biological Opinion, and the effect of the priority on June 30 refill. Model results were used to estimate the number of years out of the 50-year record when the spring flow objective at Priest Rapids Dam would be met or exceeded. The results, expressed as percentages, are summarized in Table III-1:

Table III-1. Percentage of years out of the 50-year water record when the spring flow objective at Priest Rapids Dam would be met or exceeded under four scenarios.

	Priority = June 30 Refill		**Priority = Spring Objectives**	
Period	**1995 BiOp Measures 97FSH03**[3]	**1995 BiOp & Supplement 98FSH05**	**1995 BiOp Measures 97FSH01**	**1995 BiOp & Supplement 98FSH03**
April 16 - 30	48	42	54	54
May 1 - 31	70	74	78	86
June 1 - 30	70	78	72	80
April 16 - June 30	76	80	76	82

[3] Number designates model run.

Measures to Improve Flows in the Mid-Columbia River

The Action Agencies propose to improve flows in the mid-Columbia River through additional operational measures and through inseason management actions, on a weekly basis, that are designed to optimize fish survival.[4] The planning dates for operational measures in the mid-Columbia River are April 10 through June 30. To provide an additional volume of water during the spring outmigration and to thereby achieved improved flows, the Action Agencies will operate Libby, Hungry Horse, and Grand Coulee as follows. Hungry Horse and Grand Coulee will be operated to be within one-half foot of upper rule curve (URC) with the same confidence of refill as defined in the 1995 FCRPS Biological Opinion. Libby will be operated on minimum outflows to enhance the probability of being on the URC by April 10, except for releases to meet flood control, International Joint Commission requirements at Kootenay Lake, or for power emergencies. Under some conditions (especially at Hungry Horse), operating to be at URC on April 10 can result in spill being necessary to draft to the April 30 URC elevation or can result in increased risk of local flooding. The April 10 target elevation shall be modified as necessary to achieve a reasonable balance between the risk of local flooding and the objective of being as close as possible to the April 10 URC. Spill to reach URC by April 30 is be avoided when possible to keep the projects from exceeding water quality standards for dissolved gas.

The NMFS recognizes that April 10 URC elevations, as calculated from the official April final volume runoff forecast, are generally not available until a few days before April 10. Consequently, the official April 10 URC elevations that the Action Agencies shall operate to will be based on the March final forecast. However, the Action Agencies shall modify operations based on expected changes in URCs as determined by trends associated with the March mid-month and April early-bird forecasts. These criteria revise 1995 RPA Measure 1(a) which stated that the Action Agencies would operate Libby, Hungry Horse, and Grand Coulee to be at URC on April 20, although the stated levels of confidence for these operations remain the same.

The criteria stated for Albeni Falls in 1995 RPA Measure 1(a) are not changed because the project is operated at higher winter flood control elevations per a court stipulation to evaluate kokanee (i.e., landlocked sockeye salmon) spawning and rearing, as called for in the Northwest Power Planning Council’s Fish and Wildlife Program.

Flood control operations will continue to include the ability to implement flood control shifts from Dworshak and Brownlee Reservoirs to Grand Coulee Reservoir in years when runoff conditions permit. This operation transfers system flood control from the Snake River to Grand Coulee, thereby increasing April flows in the lower Snake River when juvenile fish are

[4] Management of flow on a weekly basis is consistent with present operations in the Snake and lower Columbia Rivers.

migrating. To address the earlier migration timing of wild steelhead in the Snake River, the Action Agencies also propose to revise 1995 RPA Measure 1(g), changing the planning date for the start of flow augmentation in that reach from April 10 to April 3.

In general, NMFS' goal for flow augmentation is to operate the FCRPS to match available water to fish movement during the spring and to refill reservoirs by June 30 of each year. The March 18, 1998, draft Supplemental FCRPS Biological Opinion proposed a hard constraint of storage reservoir refill in below-average runoff years, thereby reducing spring flows. However, commenters recommended against the required refill, suggesting that the principle of adaptive management would necessitate the flexibility to provide additional flows in the spring for steelhead. The NMFS, (and some commenters) believe the available data suggest that a strong priority should be placed on refilling storage reservoirs to provide water for summer flow augmentation. However, consistent with adaptive management, NMFS agrees that it would be inappropriate at this time to place an unconditional priority on refill, prioritizing summer flow augmentation for Snake River fall chinook over spring flow augmentation for all other listed species. The conditional priority that was included in the 1995 FCRPS Biological Opinion as guidance to the TMT (p. 102) is herein reaffirmed. However, lack of refill, if recommended by the TMT, should not result in substantial departures from the summer flows that would have occurred with refill.

The actual timing of flow augmentation and refill, and the degree to which the refill objective is met will be determined by the TMT. The TMT will give consideration to stock status, fish migration characteristics, and river conditions. The timing of operations to refill reservoirs may vary with the volume of reservoir inflow. Operations to refill Libby may result in refill on a date later than June 30 in high flow years and in years when flow augmentation is required for listed Kootenai River sturgeon. Operations to refill Hungry Horse may result in refill later than June 30 in high runoff years.[5] Grand Coulee may fill by July 4 if weekend flows do not decline below the 80% level of the previous 5-day average (the general management practice during the fish passage season). Due to an earlier runoff regime, operations to refill Dworshak may result in refill before June 30.

The TMT, in recommending the shaping of flows in the mid-Columbia, should consider the desire to improve flows at Priest Rapids during the period April 10 through June 30, the desire to refill storage projects, the timing and magnitude of the juvenile migration, water temperatures, spill and total dissolved gas levels, and adult fish passage and other requirements to improve the survival of listed fish. The TMT may consider and implement flows lower than the objective during the early part of the steelhead migration when relatively few fish are present, primarily in

[5] The later refill of reservoirs prevents refill too early in a season with continued high inflows that could result in spill and therefore high total dissolved gas concentrations below the dams.

low-flow years. The TMT may provide flows greater than the objective on a weekly basis during key points in the migration, while acknowledging that flows may be lower later in the steelhead migration as necessary to reserve water for flow augmentation for summer migrants.

The planning dates April 10 through June 30 have been developed based on historic fish migration timing (Bickford 1996 and Fish Passage Center, 1991 through 1997). The TMT may recommend implementation of actions for improved fish survival (e.g., flow augmentation, spill) earlier or later than these dates based on inseason monitoring of the fish migration.

<u>Additional Water for Flow Augmentation</u>

Many commenters stated that additional volumes of water should be identified to provide a higher probability of meeting the spring flow objective in the mid-Columbia River without reducing the likelihood of meeting the flow objectives for summer-migrating fish. In response, the Action Agencies will continue their efforts to obtain additional water from FCRPS, Canadian and upper Snake River reservoirs. Additional costs associated with the measures in this section have not been evaluated.

Non-Treaty water (NTS) in Canada, managed by BPA, has been suggested as a source of additional water for flow augmentation for listed steelhead. Within the terms of the annual agreements described in 1995 RPA Measure 1(a), BPA has a firm summer, NTS release right only for water it stores in the spring. Notwithstanding the non-Treaty storage operation that was called for in 1995 RPA Measure 1(a), and the annual agreements with BC Hydro to implement this operation since 1995, BPA will consider declining the opportunity to store water in its share of non-Treaty storage during the springtime of low water years. However, this alternative operation may reduce summer flows compared to the levels that would occur under strict implementation of 1995 RPA Measure 1(a).

The Action Agencies will pursue additional summertime NTS releases from U.S. accounts, beyond the current arrangement, when flows are likely to be below flow objective levels, if mutually agreeable with BC Hydro, and if the economic impacts of additional releases are not adverse. However, there are substantial Canadian system considerations that generally diminish the availability of additional summertime releases.

In addition, the Action Agencies will continue to investigate and implement appropriate modifications to flood control operations. One such operation, in particular, involves new flood control criteria called Variable Discharge ("VARQ") at Libby and Hungry Horse projects. This revised operation is being considered in coordination with the Regional Forum and the State of Montana, sovereign tribes, Northwest Power Planning Council, and other regional interests. Implementation of VARQ has the potential to improve winter reservoir conditions and spring-time river conditions for resident fish (e.g., bull trout - proposed for listing under ESA; sturgeon - listed under ESA) and wildlife while providing higher discharges in the spring for listed anadromous species. The Action Agencies' investigation will include analyses of local and system flood control, economic impacts, resident fish and wildlife, and proposed and listed species including white sturgeon, bull trout, steelhead, and chinook species. A status report on the progress of these studies will be completed by summer 1998. Prior to implementation, the Action Agencies will complete the appropriate NEPA and ESA documentation and will coordinate with Canada under the requirements of the Columbia River Treaty.

One commenter recommended that the Action Agencies work toward normative hydrographs. A commenter also suggested that the Action Agencies should provide flows that taper off at the end of the summer season. Another recommended a sliding-scale flow objective. The 1995 FCRPS Biological Opinion contains measures which provide for volumes of water to be used for spring and summer flow augmentation under the auspices of the interagency TMT. As such, within these available augmentation volumes, the TMT has capability and flexibility to make water management decisions which provide both a normative-type hydrograph as well as a flow regime in which flows taper off at the end of the summer season. The TMT also has the ability to provide higher flows during specific periods within the limits of available water as defined by the 1995 FCRPS Biological Opinion.

2. Juvenile Fish Transportation

As described above, during consultation, NMFS and the Action Agencies responded to the recommendations of the ISAB (1998) by determining that it was appropriate to modify the transportation proposal in the Biological Assessment to a proposal which "spread-the-risk" of transportation and of inriver passage for each population of a listed ESU. Specific elements of the revised proposal for spring operations for the interim period include:

<u>Voluntary Spill at Snake River Collector Projects</u>: While NMFS was reviewing the transportation program (Appendix B) and developing a proposed action that would be consistent with the ISAB's (1998) "spread-the-risk" recommendation, comments were received from the non-federal fish & wildlife managers regarding an existing discrepancy in the definition of "low flow" levels that would trigger cessation of voluntary (i.e., planned) spill at Snake River collector projects. In 1995 RPA Measure 2, the "low flow" trigger was set at 85 kcfs at Little Goose and Lower Monumental Dams, but at 100 kcfs at Lower Granite Dam. Upon review, NMFS agreed that there was no biological basis for applying one trigger at Lower Granite and a different trigger at Little Goose and Lower Monumental Dams. The trigger at Lower Granite was set higher in the 1995 FCRPS Biological Opinion simply to increase the proportion of fish transported (thereby the Action Agencies would err on the side of more fish transported). However, the installation of extended-length screens at Lower Granite and Little Goose since 1995 has increased the proportion of fish transported under all flow conditions, obviating the need for separate flow triggers. During consultation, the Action Agencies agreed to this

modification of 1995 RPA Measure 2 and propose to implement spill at all three collector projects when seasonal average flows are projected to meet or exceed 85 kcfs.[6] The change in the spill trigger at Lower Granite Dam is a modification of 1995 RPA Measure 2.

Transportation of All Juveniles Collected at Each Snake River Collector Project: All fish collected under the Action Agencies' proposed operation will be transported. This represents a modification of 1995 RPA Measure 3 which gave the TMT the flexibility to "recommend that fish be returned to the river ... if credible evidence is presented that inriver migration will be beneficial." A proposal was made during the comment period that fish at one Snake River collector project be returned to the river. This proposal was considered and rejected on the basis of preliminary returns of control fish from the 1995 NMFS' transport versus inriver evaluation which showed a consistent pattern of decreasing returns for fish collected and then returned to the river one or more times. However, if future information shows that survival through inriver migration, including returning fish to the river, is beneficial, these data will be reviewed and discussed through the Regional Forum process. Any resulting changes in the annual operation will be memorialized through the 1995 RPA Measure 26 consultation framework or some similar process.

Another proposal made in comments was to limit transportation to no more than 50% of any one population to be consistent with the recommendations of the ISAB (1998). The NMFS sought and received clarification from the ISAB on this point in the process of completing this Supplemental FCRPS Biological Opinion. In an April 6, 1998, letter from R. Williams (ISAB chair) to B. Brown (NMFS), the ISAB clarified that they were "not recommending any specific proportion or limit for transported fish. Rather, we were recommending that transportation not be maximized as earlier proposed by several management entities." With regard to the question whether increased transportation of a particular stock would be consistent with the ISAB's recommendations in situations where the risk of migrating inriver might exceed the risk of transportation (e.g., summer passage of subyearling chinook through the Snake and lower Columbia Rivers under conditions of reduced flows and elevated water temperatures), the ISAB, in its April 6, 1998, letter to B. Brown, replied that maximizing transportation under those conditions would be consistent with its recommendation.

Experimental Transportation from McNary Dam after 1998: The NMFS has determined that the moratorium on spring collection and transportation from McNary Dam, adopted during 1995, should be continued and that the spill levels described in Table III-2 should be provided at this project. The NMFS has further determined that future research is needed on transport from McNary Dam, specifically on the response of Upper Columbia steelhead to transportation. Development and implementation of such research were considered for 1998, but were determined to be infeasible. The Action Agencies propose to work with the federal, state, and tribal salmon managers to jointly develop a transportation evaluation study plan by the end of

[6] The purpose of relying on the seasonal average forecast is to maintain consistent operations over the spring season, thereby providing consistent conditions for each population of a listed ESU.

1998 so that approved research can begin in 1999. By 1999, or at such time as a research plan is approved through the Regional Forum process, spring transport from McNary may occur for research purposes. Experimental transportation from McNary Dam, beginning in 1999, would constitute a modification of 1995 RPA Measure 4.

Once any existing problem has been identified and corrected, the goal of the interim program will be to transport a proportion of Upper Columbia River steelhead from McNary Dam. At that time, further adjustments to the collection of fish at Snake River projects may be considered through the Regional Forum process and, as appropriate, formally modified through consultation (i.e., the 1995 RPA Measure 26 Framework or some similar process) to avoid placing too high a proportion of Snake River fish into the transportation program.

The Action Agencies do not propose any change from the operation for transporting juvenile summer migrants that was described in 1995 RPA Measure 3. The Action Agencies propose to continue evaluating fall chinook transport. As before, the transportation collector projects should be operated to maximize collection and transportation (i.e., no voluntary spill except as needed for approved research) during the summer migration. In general, the switch from spring to summer spill operation will occur on or about June 20. In practice, the TMT has the discretion to make the switch earlier or later based on monitoring of inriver conditions. When more favorable spring-like flow and temperatures either end before or extend after June 20, the actual date to end spill at collector projects should be modified, continuing to spread the risk of transport versus inriver passage for spring migrants so long as favorable flow and temperature conditions persist.

Truck Transportation: With respect to the use of trucking, NMFS is reviewing the information that was the basis of the ISAB's recommendation. Based solely on the high proportion of a transported Snake River subyearling chinook that is moved by trucks (an average of 92% during 1992 through 1996), NMFS shares the ISAB's concern for this species.

Looking more closely at past practices that affected listed steelhead, NMFS noted that the switch from trucks to barges during spring generally occurred as soon as the number of fish began to increase. During 1993 through 1997, the first day of barging varied between April 11 and April 20. The NMFS did not recommend a change from this practice for 1998 because barging from the Snake River began before the final Supplemental Biological Opinion was signed.

Historically (1993 through 1997), the switch from barges back to trucks occurred between June 13 and June 17, before the bulk of the Snake River fall chinook population had reached Lower Granite Dam. At that time, collection totals at Lower Granite Dam varied from 3,000 to 8,000 fish per day. Between July 1 and August 6, daily collection totals dropped to less than 1,000 fish per day. These numbers are within the range that can be loaded into trucks under the existing density criteria, so trucking has, in the past, been used as an economical alternative to barge transport.[7]

A review of the data from 1994 through 1997, specific to wild Snake River steelhead, indicates that, if the use of barges were to be extended a little more than two weeks (i.e., if barging began on April 9 and concluded on June 24), an additional two to three percent (i.e., 10,000 to 17,000 individual) wild steelhead would be barged from the lower Snake River collector projects (Lower Granite, Little Goose, and Lower Monumental Dams) instead of being trucked.

In order to more thoroughly investigate and address the concerns raised by the ISAB, the Action Agencies propose to work within the Regional Forum to develop a comprehensive review of the use of trucks versus barges and to make and implement recommendations on the appropriate role of each method of transport by December 1, 1998. Meanwhile, for 1998, the Action Agencies further propose, insofar as funding and logistics permit, to extend barging at the three Snake River collection dams approximately two weeks so that a greater portion of the summer migration is barged.

Annual Modifications to Transport Operations: The Action Agencies propose that the above-described transport operation remain in effect for the interim period, pending reinitiation of consultation. However, the Action Agencies propose that, to the extent that ongoing studies yield new information which, taken together with the information that was already available, supports a change in operations, this new information should be reviewed in the Regional Forum. Any resulting changes will be memorialized through the RPA 26 consultation framework or some similar process. For example, as discussed under the section "Transportation of All Juveniles Collected at Each Snake River Collector Project" (above), there is reason, at present, to believe that the more times fish are collected and then returned to the river, the lower the smolt-to-adult return rate. Thus, this Supplemental FCRPS Biological Opinion establishes that all fish collected will be transported. However, if future studies were to show that this practice was unwarranted, these data would be discussed in the Regional Forum and, potentially, a new policy would be established, prior to the start of the spring outmigration.

[7] The Corps estimates a cost differential of 5.4 times (i.e., $19,200 per trip for barged fish compared to $3,580 per trip for trucked fish).

3. System Spill

The Action Agencies had proposed in their Biological Assessment to modify spill levels from those specified in 1995 RPA Measure 2. The NMFS undertook a comprehensive review of the new information regarding the effects of spill (Appendix C) including revised project-specific estimates of:

- Estimates of fish guidance efficiency (the proportion of juveniles approaching turbine intakes which are guided into bypasses);
- Total dissolved gas levels associated with spill levels at each project; and
- New spill efficiency estimates for some projects (i.e., the proportion of fish approaching a project that pass via the spillway, divided by the proportion of total flow that is spilled).

The 1995 RPA defined an 80% fish passage efficiency goal for spill but recognized that some projects would achieve a lower fish passage efficiency due to dissolved gas limits (1995 RPA Measure 2). The NMFS review indicated that, while some projects were meeting the 80% fish passage efficiency goal (i.e., proportion of fish passing by non-turbine routes), others were not. Although the levels of spill provided during 1995 through 1997 were consistent with the spill recommended in the 1995 RPA, NMFS supports additional spill on a system wide basis to provide further benefits to steelhead while also increasing the survival of Snake River spring/summer and fall chinook and sockeye. The additional spill should be provided as described below pending review of performance (i.e., spill effectiveness and efficiency) and consideration of biologically-based performance standards for project passage. The Action Agencies anticipate development of a such a standard by the end of 1999 and have agreed to provide this additional spill during the interim period. To the extent that FPE at some projects will exceed 80%, this additional spill supplements 1995 RPA Measure 2 for the interim period pending decisions on long-term actions.

The Action Agencies proposed that the actual dates of spill and flow augmentation be determined annually by the TMT based on inseason monitoring information. However, the planning dates are April 3 (modified from the April 10 planning date specified in 1995 RPA Measure 2) to June 20 and June 21 to August 31 for spring and summer, respectively, in the Snake River; April 10 to June 30 in the mid-Columbia River; and April 20[8] to June 30 and July 1 to August 31 for spring and summer, respectively, in the lower Columbia River. Initial estimates of spill levels, and the basis for each estimate, are shown below (Table III-2).

The specific spill volumes listed in Table III-2 must be viewed as approximate because the total dissolved gas levels measured at the monitoring site below each project, at a given spill level, can vary with such factors as forebay dissolved gas level, spill patterns and water temperature

[8] Review of steelhead passage information at McNary Dam indicated that the planning date of April 20 for chinook salmon is applicable to steelhead (Smolt Index Report, PIT-tag data, Fish Passage Center, Portland, Oregon). In some years, steelhead smolts reached McNary before April 20; in some years, after April 20.

changes. Also, there are many project-specific limitations on spill levels for reasons other than dissolved gas. These include adult passage, navigation, and research activities. These limitations are typically of short duration but they do reduce spill for fish passage to a limited degree. Dissolved gas and biological monitoring information, and the results of research on spill effectiveness and survival, should be reviewed annually so that specific spill levels can be developed for each project.

Table III-2. Estimated spill caps for the operations specified in this Supplemental FCRPS Biological Opinion.

Project	Estimated Spill Level [9]	Hours	Limiting Factor
Lower Granite	45 kcfs	6 pm - 6 am	gas cap
Little Goose	60 kcfs	6 pm - 6 am	gas cap
Lower Monumental	40 kcfs	6 pm - 6 am	gas cap
Ice Harbor	75 kcfs (night) 45 kcfs (day)	24 hours	nighttime - gas cap daytime - adult passage
McNary	150 kcfs	6 pm - 6 am	gas cap
John Day	180 kcfs/60%[10]	1 hour before sunset to 1 hour after sunrise	gas cap/percentage
The Dalles	64%	24 hours	tailrace flow pattern and survival concerns (study planned in 1998)
Bonneville	120 kcfs (night) 75 kcfs (day)	24 hours	nighttime - gas cap daytime - adult fallback

[9] The estimates of fish passage efficiency used to derive these spill levels are conservative in that they are based on the guidance efficiencies of hatchery spring/summer chinook instead of those estimated for wild or hatchery steelhead. Estimates for hatchery spring/summer chinook were used because the spill levels set in this Supplemental FCRPS Biological Opinion must be equally protective of the weakest listed stock present in the river during the steelhead outmigration period.

[10] The total dissolved gas cap at John Day Dam is estimated at 180 kcfs and the spill cap for tailrace hydraulics is 60%. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow. Above 300 kcfs project flow, spill discharges will be 180 kcfs (up to the hydraulic limit of the powerhouse).

Comparison of these new spill objectives with those set out in the 1995 FCRPS Biological Opinion is difficult. Whereas the previous spill objectives were defined as a spill percentage, the proposed objectives (which, in most cases, are based on the spillway flows at which gas caps are reached) are described in terms of "kcfs over the spillway." These changes are described in detail in Appendix C ("Basis for NMFS Determinations Concerning the Use of Spill as Mitigation for Operation of the Federal Columbia River Power System") and are briefly outlined for each project below.

Lower Granite: The 1995 FCRPS Biological Opinion set a spill level at Lower Granite of 80% instantaneous spill for 12 hours per day. However, under most conditions, this level of spill could not be implemented because the gas cap was reached at spillway flows of 40 kcfs. The Action Agencies now estimate that the gas cap will be reached at 45 kcfs and propose this level as the spill limit. Based on radio-tracking studies with adult chinook, performed at Lower Granite Dam during 1996 and 1997, a spill level of 45 kcfs should not adversely affect adult passage (T. Bjornn, fax to R. Kalamasz, S. Pettit, and J. Ceballos, dated April 4, 1998). At a river flow 100 kcfs, the new standard will provide an instantaneous spill level of 45 kcfs and an estimated fish passage efficiency (FPE) of 85%.

It may be necessary to consider a lower spill limit to accommodate safety concerns when juveniles are being loaded directly onto barges and the barges must be docked for extended periods. Spill operations must also consider research needs critical to the proposed evaluation of the prototype surface bypass/collector (i.e., project operations are modified to spill for 24-hours per day instead of only at night and powerhouse operations are modified to provide the required hydraulic conditions in the immediate forebay). Data from this research are critical to the long-term regional decision due by the end of 1999.

The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum is dependent on the status of generation at other projects, it may not be necessary at all times.

Little Goose: The 1995 FCRPS Biological Opinion described a spill level for Little Goose Dam of 80% instantaneous spill for 12 hours per day. As at Lower Granite Dam, the Action Agencies could not usually implement this level because the gas cap was reached at spillway flows of approximately 35 kcfs. The Action Agencies now estimate that the gas cap will be reached at 60 kcfs at this dam and propose this limit. Based on radio-tracking studies with adult chinook, performed during 1997, a spill level of 60 kcfs should not adversely affect adult passage (C. Perry, Idaho Cooperative Fish and Wildlife Research Unit [ICFWRU] fax to J. Ceballos, NMFS, dated April 9, 1998).

The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum is dependent on the status of generation at other projects, it may not be necessary at all times.

At a river flow of 100 kcfs, the new standard will provide an instantaneous spill level of 60 kcfs and an estimated of FPE of 86%.

Lower Monumental: The 1995 FCRPS Biological Opinion set a spill level at Lower Monumental Dam of 81% of instantaneous spill for 12 hours per day. Again, this level of spill was not provided voluntarily because the gas cap was reached at spillway flows of approximately 40 kcfs. The Action Agencies have not changed this estimate of spill at the gas cap. Therefore, spill levels at this dam are not expected to change during 1998. Based on radio-tracking studies with adult chinook, performed during 1997, a spill level of 40 kcfs should not adversely affect adult passage (C. Perry, ICFWRU, fax to J. Ceballos, NMFS, dated April 9, 1998). Because the gas cap is currently reached at approximately 40 kcfs, no reduction in spill is necessary between 0500 to 0600 hours. Because spill is limited, the maximum achievable FPE is limited to approximately 61%.

The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum is dependent on the status of generation at other projects, it may not be necessary at all times.

Ice Harbor: The 1995 FCRPS Biological Opinion described spill levels at Ice Harbor Dam of 27% in the spring and 70% in the summer, each for 24 hours per day. The 27% spring objective was often reached, even though the gas cap limited voluntary spill to flows of 25 kcfs. The summer target of 70% was also reached at the lower flow levels. Due to the installation of spillway flow deflectors, the Action Agencies now estimate that the gas cap will be reached at 75 kcfs. Based on research performed during the early 1980's, concerns for adult passage would limit daytime (0500 to 1800) spill to 45 kcfs. However, in view of preliminary information from radio-tracking studies performed during 1996, wherein a spill level higher than 45 kcfs did not adversely impact adult passage (C. Perry, ICFWRU, fax to J. Ceballos, NMFS, dated April 9, 1998), may require that the 45 kcfs adult passage daytime cap may need to be reconsidered once the final results are available. However, no change is proposed at this time. Additional short-term limits may need to be imposed to address safety concerns when barges are exiting the lock in the downstream direction. Temporary modifications to FPP spill patterns to improve navigation conditions will not be necessary once coffer cell construction below the spillway is completed this coming winter. At a river flow of 100 kcfs, the new standard will provide an instantaneous spill level of 75 kcfs and an estimated spring chinook FPE of 84%.

The BPA has specified 7.5 to 9.5 kcfs as minimum powerhouse flows for system reliability. Because this minimum is dependent on the status of generation at other projects, it may not be necessary at all times.

McNary: The 1995 FCRPS Biological Opinion set a spill level at McNary Dam of 50% for 12 hours per day. Due to limited powerhouse capacity and because the gas cap was reached at spillway flows 120 kcfs, these spill levels were reached under most conditions. The Action Agencies now estimate that the gas cap will be reached at 150 kcfs and proposed this level of spill as the limit. At a river flow of 240 kcfs, the new standard will provide an instantaneous spill level of 150 kcfs and an estimated FPE of 89%.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

John Day: The 1995 FCRPS Biological Opinion set spill levels of 33% during spring and 86% during summer, 12 hours per day. The gas cap was reached at spillway flows of 20 to 50 kcfs (depending on the spill pattern), prohibiting voluntary spill under most river flow conditions. Because of spill flow deflectors have been installed at this project, the Action Agencies now estimate that the gas cap will be reached at spillway flows of approximately 180 kcfs. The Action Agencies therefore propose a spill limit of 180 kcfs except when river flows are less than approximately 250 to 300 kcfs. At these low flows, poor tailrace conditions at the bypass outfall will limit spill to 60% of the total river flow.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

A change in hours to one hour before sunset to one hour after sunrise is also proposed to partially offset the high cost of the increased spill levels at John Day. At a river flow of 240 kcfs, the new standard will provide an instantaneous spill level of 60% and an estimated spring chinook FPE of 79%, from one hour before sunset to one hour after sunrise

The Action Agencies also propose to investigate 24-hour spill at John Day Dam beginning in 1999. The cost and transmission system effects of 24-hour spill at John Day are a concern. However, high spillway effectiveness and high daytime passage were noted during 24-hour spill in 1997 (Corps Memorandum for the Record from Bob Dach, February 3, 1998). This observation, together with the need to evaluate the slight change in spill hours, warrants further investigation. Spill effectiveness was highest during the summer but daytime passage was much higher than expected during both spring and summer, indicating a potential decrease in forebay residence time (and subsequent predator exposure) in this area. The framework for the proposed study is as follows: (1) the study will not exceed two years; (2) the scope of the study will include both spring and summer spill; (3) the test condition will not necessarily involve 24 hour spill seven days per week (i.e., 24-hour spill will be limited temporally in season so as to generate the necessary information with minimal effects on generation and transmission capacity); (4) the study plan will be approved through the Regional Forum process.

Commenters suggested that the 24-hour spill test should be conducted at John Day during 1998. However, it would not be reasonable to implement this test during 1998 because the necessary planning cannot be completed.

The Dalles: The 1995 FCRPS Biological Opinion set a spill level at The Dalles Dam of 64% for 24 hours. Because the gas cap was reached at spillway flows of 230 kcfs, the Opinion spill level was met most of the time. Whereas spill could be increased further before the gas cap was reached, poor tailrace conditions and recent poor survival estimates at high spill volumes are a concern. No change is proposed until planned survival and spill effectiveness studies, planned for 1998, can be completed. However, changes in spill operations at The Dalles may be proposed once this research is completed. Any resulting changes in the annual operation will be coordinated through the Regional Forum process and memorialized through the 1995 RPA Measure 26 consultation Framework or some similar process. At a river flow of 240 kcfs, 64% spill will provide an estimated FPE of 79%.

The BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

Bonneville: The 1995 FCRPS Biological Opinion did not recommend specific spill percentages at Bonneville Dam because spill was limited severely by the need for measures to prevent adult fallback. In addition, the gas cap was reached at 120 kcfs spillway flow. Research is to address these issues is needed and no change in spill is proposed at this time. At a river flow of 240 kcfs, the limited spill capability will provide an estimated FPE of 59%.

The BPA has specified a minimum powerhouse flow of 30 kcfs.

4. Feasibility Studies for Long-Term Alternative System Configurations in the Lower Columbia River

The Action Agencies propose to continue to investigate surface bypass technology, guidance efficiency improvements, and other system improvements at Bonneville, The Dalles, John Day and McNary Dams, and to integrate this information into a comprehensive feasibility study for the long-term configuration of the lower Columbia River reach (Lower Columbia River System Configuration Study). The objective of the study would be to complete comprehensive scoping, feasibility, design, and engineering work for potential alternative configurations of lower Columbia River projects that will improve the survival of proposed and listed anadromous species.[11] The study plan will be developed by the Action Agencies in coordination with the Regional Forum.

As an initial step, the Action Agencies and NMFS will work through the Regional Forum process to develop biological goals for the lower Columbia River reach. The biological goals will be used to formulate and select alternatives, including specific flow augmentation operations, for further detailed study. Results and recommendations from the Lower Snake River Final Feasibility Study, scheduled for completion in late 1999, will be considered in selecting alternatives for

[11] The evaluation of alternative configurations would address water quality concerns to the extent that they affect listed fish.

further detailed studies. A status report of the preliminary engineering studies and biological evaluations, which narrows down the alternatives for each project in the lower Columbia River reach, will be completed by mid-2000. The final feasibility study would include the appropriate NEPA and ESA documentation and, if necessary, recommendations to Congress for authorization and implementation of a selected plan for the lower Columbia River reach by 2004. At a minimum, the alternatives will include:

Drawdown: A scoping document for John Day Drawdown Study was prepared by the Corps during late 1997 and early 1998. It was transmitted, on February 12, 1998, to congressional committees in response to the FY 1998 Energy and Water Development Appropriations Bill. If the Corps receives congressional direction to evaluate drawdown at John Day, the evaluation will include both spillway crest and natural river level drawdown, as identified in the scoping document.

In the ISG's "Return to the River" (1996), drawdown at the McNary project was discussed as a potential measure to improve the survival of anadromous species. Study of McNary drawdown is not part of the proposed FY 1999 budget, nor has the scope of McNary drawdown been discussed in the Regional Forum process. Prior to initiating any study of McNary drawdown, the Corps would notify the appropriate congressional committees and would initiate discussion in the Regional Forum process. The Action Agencies propose to take these steps in further planning for FY 1999. If congressional appropriations permit, the evaluations at McNary will include drawdown to natural river level.

As part of the evaluation of the potential benefits of drawdowns of mainstem Columbia River reservoirs, the Action Agencies will coordinate with the PUDs on investigations of the travel time and survival of wild and hatchery steelhead smolts through the free-flowing Hanford reach.

Maximum Spill: The Action Agencies propose to evaluate a "maximum spill with gas abatement" alternative to determine the potential to implement a major improvement in survival through the four lower river projects without drawdown. In field evaluations, spill has consistently provided maximum juvenile migrant survival past dams relative to other routes of passage. However, the adverse effects of dissolved gas and the effects on adult fishway entrance requirements and tailrace hydraulic patterns on adult and juvenile migrants limit the amount of water that can be spilled. Selection of a maximum spill alternative will therefore consider a broad range of potential project modifications to address these considerations while maximizing spillway passage. This information will be incorporated into the on-going Gas Abatement Study.

Full Flow Bypass: The Action Agencies propose to evaluate juvenile bypass outfall criteria and, based on research findings, to develop appropriate criteria for potential full-flow bypass of juvenile salmonids without any handling.

Surface Bypass Collection: The Action Agencies propose to evaluate surface bypass collection alternatives including the on-going evaluations of skeleton bays at John Day Dam, the surface bypass prototype at Bonneville Dam First Powerhouse, and surface bypass options at The Dalles Dam. Further application of surface bypass collection and physical guidance devices at all four lower Columbia River projects will also be evaluated.

Improved Transportation: The Action Agencies propose to evaluate structural and operational alternatives to improve juvenile transportation at McNary. These alternatives could include the construction of additional barges to expand the capacity for direct loading or improvements to the juvenile bypass system.

Other System Improvements: The Action Agencies propose to continue the on-going evaluations of fish guidance efficiency improvements at Bonneville Dam First and Second Powerhouses, and relocation of the ice and trash sluiceway outfall at The Dalles. The deferred design of the mechanical bypass system at The Dalles, and other juvenile bypass improvements will be included in the comprehensive analysis. The following specific actions will be evaluated for Bonneville Dam: (1) improvements in fish guidance efficiency, (2) the ability to operate the Second Powerhouse independently from the First Powerhouse (the Corps has made structural modifications necessary to shift station service to the Second Powerhouse per the 1995 FCRPS Biological Opinion but there are additional transmission system modifications needed before the powerhouses can be operated independently (3) structural and operational modifications to reduce fallback (e.g., modifications to adult passage facilities), and (4) turbine modifications (intake to draft tube exit) that could improve fish passage survival.

5. Analytical Techniques and Data for Consultation on Long-term Operations of the FCRPS

The Action Agencies propose to fund a regionally-coordinated analysis through a forum such as the Plan for Analyzing and Testing Hypotheses (PATH), and fully coordinated with the ongoing PATH process, to determine the effects of the proposed action in the context of the species-level biological requirements (i.e., over the entire life history) of listed steelhead ESUs. This analytical effort will also develop the information needed to integrate the species-level biological requirements of steelhead into a multispecies recovery plan for the Columbia River basin. The NMFS will apply the PATH analyses in developing (by the end of 1999) its recommendations regarding long-term configurations of FCRPS projects on the lower Snake River that are likely to result in the survival and recovery of listed salmonids. The NMFS will also apply the PATH analyses to a later recommendation regarding the operation of FCRPS projects on the lower Columbia River.

In Section V of this Supplemental FCRPS Biological Opinion, we describe a shortage of tools for analyzing the effects of the proposed action in the context of the species-level biological requirements of listed steelhead ESUs. Interim analytical techniques have been employed to assess the effects of the proposed action on Snake and Upper Columbia River steelhead for the purposes of this Supplemental FCRPS Biological Opinion, but these techniques must be validated and developed further through an expanded analytical effort. Further, it has not yet been possible to develop even interim techniques for Lower Columbia River steelhead. The development of methods specific to this ESU are critical. The PATH analytical group will develop these techniques over the next two years to allow completion of a biological opinion addressing the long-term operation of the FCRPS during 2000 and future years.

6. Intervention Using Artificial Propagation to Preserve Genetic Diversity of Listed Steelhead

On August 18, 1997, the NMFS listed steelhead of the Upper Columbia ESU as endangered and steelhead of the Snake River Basin ESU as threatened. On March 19, 1998, steelhead of the Lower Columbia ESU were listed as threatened and steelhead of the Mid-Columbia ESU were proposed for listing as threatened. It is likely that, by the end of 1999, all native, naturally spawned steelhead in the Columbia River Basin, within the action area for the FCRPS, will be listed under the Endangered Species Act. It may become necessary to intervene using artificial propagation to conserve genetic resources of listed steelhead stocks. Therefore, the Action Agencies will continue to fund research aimed at evaluating and refining supplementation technology, including captive broodstocks, for depleted anadromous salmonid stocks. The Action Agencies will provide funding for artificial propagation if such is consistent with their biological analyses, NMFS' recommendation, and a risk assessment by the comanagers that calls for such measures. The objectives of artificial propagation will be to preserve diverse indigenous genetic material until the natural productivity of steelhead populations improves.

B. Issuance of Section 10 Permits by NMFS

1. Modification of the Section 10 Permit for the Juvenile Transportation Program

The Corps of Engineers, Walla Walla District, applied to NMFS for a modification of Permit 895 under authority of section 10 of the ESA and the NMFS regulations governing ESA-listed fish and wildlife permits (50 CFR parts 217 through 227). Permit 895 authorizes the Corps annual direct takes of juvenile, endangered Snake River sockeye salmon (<u>Oncorhynchus</u> <u>nerka</u>); juvenile, threatened, naturally-produced and artificially-propagated, Snake River spring/summer chinook salmon (<u>O</u>. <u>tshawytscha</u>); and juvenile, threatened, Snake River fall chinook salmon (<u>O</u>. <u>tshawytscha</u>) associated with the Corps' juvenile fish transportation program at four hydroelectric projects on the Snake and Columbia Rivers (Lower Granite, Little Goose, Lower Monumental, and McNary Dams). Permit 895 also authorizes the Corps' annual incidental takes of ESA-listed adult fish associated with fallbacks through the juvenile fish bypass systems at the four dams.

For modification 4 to the permit, the Corps requests (1) annual direct takes of juvenile, endangered, naturally-produced and artificially-propagated, upper Columbia River steelhead (Oncorhynchus mykiss) and juvenile, threatened, Snake River steelhead (Oncorhynchus mykiss) associated with the transportation program and (2) annual incidental takes of ESA-listed adult steelhead associated with fallbacks through the juvenile bypass system. ESA-listed steelhead indirect and incidental mortalities associated with the transportation program are requested. Also, for modification 4, the Corps requests an extension of the expiration date of permit 895 to December 31, 1999. Permit 895 is currently due to expire on December 31, 1998. The Corps is conducting a feasibility study to evaluate several alternatives to juvenile fish transport, scheduled to be completed by late 1999. An extension of permit 895 through December 31, 1999, would allow the duration of the permit to coincide with the completion of the feasibility study.

The public comment period on the Corps' permit application ended on March 27, 1998. The NMFS expects to issue the requested modification to Permit 895 after this biological opinion is signed.

2. Modification of the Section 10 Permit for the Smolt Monitoring Program

The Fish Passage Center (FPC) has applied to NMFS for a modification to Permit 822 which authorizes the FPC annual direct takes of juvenile, endangered Snake River sockeye salmon (Oncorhynchus nerka); juvenile, threatened, naturally-produced and artificially-propagated, Snake River spring/summer chinook salmon (O. tshawytscha); and juvenile, threatened, Snake River fall chinook salmon (O. tshawytscha) associated with the Smolt Monitoring Program that is conducted at hydropower dams on the Snake and Columbia Rivers and a number of upriver locations in the state of Idaho. Permit 822 also authorizes the FPC annual incidental takes of ESA-listed adult Snake River salmon associated with fallbacks through the juvenile bypass systems at Bonneville and John Day Dams on the Columbia River.

For modification 5 to the permit, the FPC requests (1) annual direct takes of juvenile, endangered, naturally-produced and artificially-propagated, upper Columbia River steelhead (Oncorhynchus mykiss) and juvenile, threatened, Snake River steelhead (Oncorhynchus mykiss) associated with the SMP; (2) an annual direct take of juvenile lower Columbia River steelhead (Oncorhynchus mykiss), a species currently proposed as threatened, at Bonneville Dam; and (3) annual incidental takes of ESA-listed adult steelhead associated with fallbacks through the juvenile bypass systems at Bonneville and John Day Dams. ESA-listed steelhead indirect and incidental mortalities associated with the SMP are requested. Modification 5 to Permit 822 is requested to be valid for the duration of the permit. Permit 822 is currently due to expire on December 31, 1998. An extension of permit 822 through December 31, 1999, would allow the duration of the permit to coincide with the completion of the feasibility study.

The public comment period on the Fish Passage Center's permit application ended on April 6, 1998. The NMFS expects to issue the requested modification to Permit 822 after this biological opinion is signed.

C. Duration of the Proposed Actions

The duration of the proposed actions is intended to be coincident with the interim period described in the 1995 FCRPS Biological Opinion. The timing of the decision regarding the long-term configuration of FCRPS projects on the lower Snake River (scheduled for late 1999) is also unchanged from the 1995 opinion. We anticipate reinitiation of this consultation at that time.

IV. BIOLOGICAL INFORMATION

A. List of species

1. Snake River Steelhead

The NMFS listed this inland steelhead ESU, which occupies the Snake River basin of southeast Washington, northeast Oregon, and Idaho, as threatened on August 18, 1997 (62 FR 43937). The Snake River flows through terrain that is warmer and drier on an annual basis than the upper Columbia Basin or other drainages to the north. Collectively, these environmental factors result in a river that is warmer and more turbid, with higher pH and alkalinity, than is found elsewhere within the range of inland steelhead.

Snake River Basin steelhead, like most inland steelhead, are summer-run. Two groups, A-run and B-run, are defined based on the timing of their respective adult migrations, ocean-age, and size at maturity. Snake River Basin steelhead enter fresh water from June to October and spawn in the following spring from March to May. A-run steelhead are thought to be predominately l-ocean, while B-run steelhead are thought to be 2-ocean (IDFG 1994). Snake River Basin steelhead usually smolt at age-2 or -3 years (Whitt 1954; BPA 1992; Hassemer 1992).

Run-timing separation is not observed once the Snake River run is above Bonneville Dam. Above this point, the groups are separated by ocean age and body size (IDFG 1994). It is unclear if the life history and body size differences observed upstream can be correlated with the groups that form the bimodal migration observed at Bonneville Dam. Furthermore, the relationship between patterns observed at the dams and the distribution of adults in spawning areas through the Snake River basin is not well understood.

2. Upper Columbia River Steelhead

This inland steelhead ESU occupies the Columbia River Basin upstream from the Yakima River, Washington, to the United States' border with Canada. The NMFS listed the Upper Columbia River ESU as endangered on August 18, 1997 (62 FR 43937). The geographic area occupied by this ESU forms part of the larger Columbia Basin Ecoregion (Omernik 1987). The Wenatchee and Entiat Rivers are in the Northern Cascades Physiographic Province and the Okanogan and Methow Rivers is in the Okanogan Highlands Physiographic Province. Mullan et al. (1992), describing this area as a harsh environment for fish, stated that "it should not be confused with more studied, benign, coastal streams of the Pacific Northwest."

Life history characteristics for Upper Columbia River Basin steelhead are similar to those of other inland steelhead ESUs; however, some of the oldest smolt ages for steelhead, up to seven years, are reported from this ESU. Mullen et al. (1992) suggested that this longevity may be associated with cold stream temperatures. Based on the limited data available, smolt age in this ESU is dominated by two-year-olds. Steelhead from the Wenatchee and Entiat Rivers return to fresh water after one year in salt water, whereas Methow River steelhead are primarily 2-ocean resident (Howell et al. 1985).

In 1939, the construction of Grand Coulee Dam on the Columbia River (RKm 956) blocked over 1,800 km of river from access by anadromous fish (Mullan et al. 1992). During 1939 through 1943, in an effort to preserve fish runs affected by Grand Coulee Dam, all anadromous upstream migrants were trapped at Rock Island Dam (RKm 729) and either released to spawn in tributaries between Rock Island and Grand Coulee Dams or spawned in hatcheries and the offspring were released in that area (Peven 1990; Mullan et al. 1992; and Chapman et al. 1994). Through this process, stocks of all anadromous salmonids, including steelhead, which historically were native to several separate subbasins above Rock Island Dam, were redistributed among tributaries in the Rock Island-Grand Coulee reach. The degree and manner in which this action has affected the genetic composition of steelhead stocks that currently spawn in the wild are unknown.

3. Lower Columbia River Steelhead

This coastal steelhead ESU occupies tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington, inclusive, and the Willamette and Hood Rivers in Oregon, inclusive. Steelhead in the upper Willamette River Basin above Willamette Falls and steelhead from the Little and Big White Salmon Rivers in Washington are excluded. The NMFS listed these fish as threatened on March 19, 1998 (63 FR 13347).

Steelhead populations in this ESU are of the coastal genetic group (Schreck et al. 1986, Reisenbichler et al. 1992, and Chapman et al. 1994). A number of genetic studies have shown that they are part of a different ancestral lineage than inland steelhead from the Columbia River Basin. Genetic data also show steelhead from this ESU to be distinct from steelhead from the upper Willamette River and coastal streams in Oregon and Washington. Data developed by the Washington Department of Fish and Wildlife show genetic affinities between Kalama, Wind, and Washougal River steelhead. These data show differentiation between the Lower Columbia River ESU and the Southwest Washington and Middle Columbia River Basin ESUs. This ESU is composed of winter steelhead and summer steelhead.

B. Species Life Histories and Historical Population Trends

Steelhead exhibit one of the most complex life histories of any salmonid species. Steelhead may exhibit anadromy (i.e., migrate as juveniles from fresh water to the ocean and then return to spawn in fresh water) or freshwater residency (reside their entire life in fresh water). Resident forms are usually referred to as "rainbow" or "redband" trout, while anadromous life forms are termed "steelhead." Because few detailed studies have been conducted regarding the relationship between resident and anadromous O. mykiss, the relationship between these two life forms is poorly understood.

Steelhead typically migrate to marine waters after spending two years in fresh water. They then reside in marine waters for two or three years prior to returning to their natal stream to spawn as 4- or 5-year-olds. Unlike Pacific salmon, steelhead are iteroparous, meaning they are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying and most that do so are females. Steelhead adults typically spawn between December and June (Bell 1990 and Busby et al. 1996). Depending on water temperature, steelhead eggs may incubate in "redds" (nesting gravels) for 1.5 to 4 months before hatching as "alevins" (a larval life stage dependent on food stored in a yolk sac). Following yolk sac absorption, alevins emerge from the gravel as young juveniles or "fry" and begin actively feeding. Juveniles rear in fresh water for one to four years, then migrate to the ocean as "smolts."

Biologically, steelhead can be divided into two reproductive ecotypes, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration. These two ecotypes are termed "stream maturing" and "ocean maturing." Stream maturing steelhead enter fresh water in a sexually immature condition and require several months to mature and spawn. Ocean maturing steelhead enter fresh water with well-developed gonads and spawn shortly after river entry. These two reproductive ecotypes are more commonly referred to by their season of freshwater entry (e.g., summer and winter steelhead).

Two major genetic groups or "subspecies" of steelhead occur on the west coast of the United States: a coastal group and an inland group, separated in the Fraser and Columbia River Basins by the Cascade crest approximately (Huzyk & Tsuyuki 1974: Allendorf 1975; Utter & Allendorf 1977; Okazaki 1984; Parkinson 1984; Schreck et al. 1986; Reisenbichler et al. 1992). Both coastal and inland steelhead occur in Washington and Oregon. California is thought to have only coastal steelhead while Idaho has only inland steelhead.

Historically, steelhead were distributed throughout the North Pacific Ocean from the Kamchatka Peninsula in Asia to the northern Baja Peninsula. Presently, the distribution of the species extends from the Kamchatka Peninsula and east and south along the Pacific coast of North America at least as far as Malibu Creek in southern California. There are infrequent anecdotal reports of steelhead continuing to occur as far south as the Santa Margarita River in San Diego County (McEwan & Jackson 1996). Historically, steelhead probably inhabited most coastal streams in Washington, Oregon, and California as well as many inland streams in these states and Idaho. However, during this century, more than 23 indigenous, naturally-reproducing stocks of steelhead are believed to have been extirpated, and many more are thought to be in decline in numerous coastal and inland streams in Washington, Oregon, Idaho, and California. Forty-three stocks have been identified by Nehlsen et al. (1991) as at moderate or high risk of extinction.

V. EVALUATING PROPOSED ACTIONS

In the FCRPS Biological Opinion NMFS described a five-part approach to applying the jeopardy standards in the implementing regulations of the Endangered Species Act to Pacific salmon. The same general approach is applied to determinations for listed steelhead ESUs in this Supplemental FCRPS Biological Opinion. The analysis involves the following steps:

(1) Define the biological requirements of the listed species;

(2) Evaluate the relevance of the environmental baseline to the species' current status;

(3) Determine the effects of the proposed or continuing action on listed species;

(4) Determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the proposed or continuing action, the environmental baseline and any cumulative effects, and considering measures for survival and recovery specific to other life stages; and

(5) Identify reasonable and prudent alternatives to a proposed or continuing action that is likely to jeopardize the continued existence of the listed species.

Details of the applications of each step of this analysis are presented in the following sections.

V.A. Biological Requirements for Listed Species

V.A.1. Biological Requirements Within the Action Area

V.A.1.a. Snake River Steelhead

The action area relative to Snake River steelhead is described as the migration corridor in the Snake and Columbia Rivers, from the farthest upstream points at which listed steelhead are affected by federal water management (i.e., below the Hells Canyon complex on the mainstem Snake River and below Dworshak Dam on the lower Clearwater River) to the farthest downstream point (the Columbia River plume and the nearshore ocean environment) at which listed steelhead are influenced by federal water management (the Columbia River plume and the nearshore ocean environment).

It is reasonable to assume that, within the action area, the biological requirements of juvenile Snake River steelhead are very similar to those of other juvenile salmonids in the Snake River and Columbia River migration corridor. These biological requirements stem from the essential features of the juvenile migration corridor, as described in the critical habitat designation for Snake River spring/summer chinook salmon, fall chinook salmon, and sockeye salmon (58 FR

68543). Therefore, the biological requirements of juvenile Snake River steelhead include: (1) an adequate substrate; (2) adequate water quality; (3) adequate water quantity; (4) adequate water temperature; (5) adequate water velocity; (6) adequate cover and shelter; (7) adequate food; (8) adequate riparian vegetation; (9) adequate space; and (10) conditions for safe passage.

Further, it is reasonable to assume that biological requirements of adult Snake River steelhead within the action area are very similar to those of other adult salmonids in the Snake River and Columbia River migration corridor. These requirements are the same as those described for juveniles, with the exclusion of (7) adequate food.

V.A.1.b. Upper Columbia River Steelhead

The action area, relative to Upper Columbia River steelhead, is described as the Columbia River migration corridor from the farthest upstream point at which listed steelhead are affected by Federal water management (i.e., the mainstem Columbia River below Chief Joseph Dam) to the farthest downstream point (the Columbia River plume and the nearshore ocean environment) at which listed steelhead are influenced by federal water management.

The biological requirements of adult and juvenile Upper Columbia River steelhead are the same as those described for Snake River steelhead.

V.A.1.c. Lower Columbia River Steelhead

The action area relative to Lower Columbia River steelhead is described as the Columbia River migration corridor from the farthest upstream point at which listed steelhead are affected by Federal water management (i.e., the mainstem Columbia River below its confluence with Hood and Wind Rivers, in Bonneville Reservoir) to the most downstream point (the Columbia River plume and the nearshore ocean environment) at which listed steelhead are influenced by federal water management.

The biological requirements of adult and juvenile Lower Columbia River steelhead are the same as those described for Snake River steelhead.

V.A.2 Biological Requirements That Apply to All Actions and Action Areas

V.A.2.a. Snake River Steelhead

At the species level, steelhead biological requirements are the population numbers, trends, geographic distribution, and genetic variability that are sufficient to ensure survival with an adequate potential for recovery. Survival and recovery are defined as discussed in the 1995 FCRPS Biological Opinion, Section 1b:

> **Survival**: the species' persistence, beyond conditions leading to its endangerment, with sufficient resilience to allow recovery. Said another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficiently large population, represented by all age classes, genetic heterogeneity, and a number of sexually mature individuals producing viable offspring, that exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter.

> **Recovery:** improvement in the status of a species and the ecosystems upon which they depend. Said another way, recovery is the process by which species' ecosystems are restored so they it can support self-sustaining and self-regulating populations of listed species as persistent members of native biotic communities.

Knowledge of the species-level biological requirements allows assessment of the "adequacy" of the action-area biological requirements (see Section V.A.1.a, above) within the context of the full life cycle. This "adequacy" is a function of both the life history of the stock under consideration and the current status of that stock. For example, populations of stream-type chinook salmon, experience relatively high mortality during their extended freshwater-tributary rearing phase and pass through the migration corridor at a relatively large size. Ocean-type chinook salmon, which experience lower tributary mortality during the short period prior to emigration, pass through the migration corridor at a smaller size. Therefore, stream-type chinook may be expected to experience lower total migration corridor mortality under natural conditions than do ocean-type chinook salmon. Overall, each life history type has similar general biological requirements in each life-history stage, but the distribution of mortality among those stages may differ among the stocks. Similarly, a stock at a level of abundance near theoretical maximum sustainable production is likely to be able to sustain greater (human caused) migration corridor mortality than a stock that is at a very low population level.

In the 1995 FCRPS Biological Opinion, the definition of species-level biological requirements for Snake River chinook salmon required the estimation of the "threshold," stock-specific spawner-abundance levels required for continued survival of at least several of the representative populations comprising the evolutionarily significant unit (ESU) and the recovery population level. There are several reasons why applying the estimates of populations levels for Snake River chinook to Snake River steelhead are problematic at this time. For example, the "threshold" levels for Snake River chinook were defined at least partially by the levels at which population simulation model behavior was uncertain and such simulation models currently do not exist for Snake River steelhead. Also, recovery population levels associated with delisting Snake River chinook were developed by the Snake River Recovery Team and NMFS following a multi-year process. Recovery population levels for Snake River steelhead have not yet been defined. It is possible that threshold values will be suggested through the multi-agency Plan for Analyzing and Testing Hypotheses (PATH) process, in which case these estimates will become available during late 1998 or 1999. However recovery levels are unlikely to be defined until NMFS develops proposed delisting criteria, which may take several years.

Until the PATH analysis is complete and recovery levels are defined, NMFS intends to apply an interim performance index, believed to be indicative of the population levels required for survival and recovery. The application of this index is discussed below in Section V.D.2. This interim performance measure is currently being developed in cooperation with the PATH analytical group. The performance measure is:

Historical Smolt-to-Adult Return Rates (SAR): Smolt-to-Adult return rates are a way of using readily available data to address what is conceptually a very simple question. Given a specific number of smolts migrating from a particular tributary at low seeding levels, what fraction of that number of smolts must return as adults to produce a greater number of smolts outmigrating in the next generation? Once the run is rebuilt, smolt-to-adult survivals at this rate would be expected to sustain the run at healthy levels. This survival rate is estimated as a range to reflect year-to-year variations in environmental conditions. It is important to remember that survival through the smolt-to-adult life stages incorporates a combination of human-induced mortality from several sources (e.g., dam passage, water management, harvest, estuarine/riverine habitat modifications, and water quality modifications) as well as natural mortality associated with conditions in the river, estuary, and ocean. The SAR does not explicitly incorporate survival throughout the entire life cycle, as does the simulation modeling conducted by PATH for Snake River spring/summer chinook salmon. That is, the SAR analysis does not incorporate the survival rate of adults from the time they pass above the upper dam until spawning or the survival of their progeny until these reach the upper dam as smolts. Therefore, the range of SARs must be chosen to provide a high enough rate of survival through the smolt-to-adult life stages that overall survival throughout the life cycle will be adequate for the species to persist and recover.

The only currently available method of identifying the range of SARs adequate for survival and recovery of an ESU is to look at the SARs that were achieved historically, when the ESU was at recovery population levels and survival rates were not declining. The PATH analytical group has suggested a correspondence between the SARs of aggregate Snake River spring/summer chinook stocks during the 1960s, when these stocks appeared to be “healthy” (i.e., experiencing high survival, with populations at or near the proposed recovery levels), and the ability of the stocks to persist and recover (Chapter 6 in Marmorek et al. 1996). A PATH subcommittee suggested an interim SAR goal of two to six percent until more quantitative analyses of stock performance could be completed. The PATH interim SAR goal was derived from consideration of three different approaches: (1) estimates of Snake River spring/summer chinook SARs to the upper dam during a relevant historical period; (2) back-calculation of theoretical SARs from Snake River spawner-to-smolt survival estimates; and (3) comparison with SARs from a lower Columbia River stock (Warm Springs). The first method has the greatest potential for application to other species, because, for example, spawner-to-smolt survival estimates are not available for most steelhead stocks and steelhead SARs do not exist for the Warm Springs stock. This was implemented in Chapter 6 in Marmorek et al. (1996) by considering both Raymond’s (1988) estimates, which were expressed as (SAR to upper dam)/(1-Harvest) for wild Snake River spring and summer chinook stocks during the 1960s, and by estimating SAR to the upper dam by multiplying Raymond’s (1988) estimates by (1- average harvest rates during the 1960s). This calculation, using approximate harvest rates, yielded SARs to the upper-most dam ranging from two to four percent for Snake River spring chinook and from two to five percent for Snake River summer chinook (Chapter 6 in Marmorek et al. 1996). Raymond's (1988) method resulted in estimates ranging from approximately three to six percent during the same period.

Some recent work by PATH supports the idea that historical SARs may reasonably approximate the acceptable probabilities of survival and recovery for Snake River spring/summer chinook salmon. Preliminary simulation model analyses by PATH suggest a correspondence between median SARs ranging from two to seven percent and a probability of at least 70% (i.e., meeting or exceeding this part of the NMFS jeopardy standard) that most index stocks will be above threshold survival levels over a 100-year period (Marmorek and Peters 1998 - Draft Report). Future PATH analyses are expected to determine whether historical `SARs correspond to acceptable probabilities of being above threshold levels over a 24-year period or to acceptable probabilities of meeting recovery levels within 48 years.

A subcommittee of PATH has been working with NMFS to estimate "historical SARs" of Snake River spring/summer chinook salmon using a more explicit methodology than that applied in Chapter 6 in Marmorek et al. (1996). The purpose of developing this more explicit approach is to facilitate application of the technique to other species. Four key questions were identified in development of this approach.

First, what is the specific historical period that was associated with a "healthy population?" The tentative conclusion of the working group, based upon an inspection of trends in SARs and escapement, is that the period prior to the 1970 smolt outmigration is most closely associated with healthy population levels of wild Snake River spring/summer chinook salmon. This period, which preceded a sharp decline in both wild spring/summer chinook survival and spawner escapement, began with, or followed shortly after, the 1970 outmigration (see Figure 4 in Raymond 1988). The earliest smolt outmigration year for which historical SARs are available is 1964. Therefore, the historical time period corresponding to the necessary SAR is defined as 1964 through 1969.

Second, what is the appropriate definition of SAR? The two historical SAR definitions described in Chapter 6 in Marmorek et al. (1996) were considered by the PATH subcommittee, but consensus has not yet been reached regarding the most appropriate definition to use as a surrogate for an acceptable probability of survival (spawning escapement above threshold escapement levels) and recovery. The PATH group is expected to make a formal recommendation when its final steelhead report is completed. Until then, NMFS applies both with equal weight in this biological opinion. It does not appear that differences between the two definitions result in different conclusions in the application of the jeopardy standard in this consultation, assuming that both are applied consistently to the historical and recent time periods as described in Section V.D.2. Under either definition of SAR the conclusions of Section VI.A.4 (below) are supported. Briefly, the two definitions are as follows.

Smolt-to-adult return rate to the upper dam ("Escapement SAR"). This first definition is simply the number of adults from a given outmigration year that returned to the most upstream dam, divided by the number of smolts that passed the same dam during the outmigration year. This SAR definition is estimated for each year during the historical period when escapement and survival rates were considered adequate for species persistence and recovery. This SAR definition does not directly assume a particular level of harvest, although the harvest rates that occurred during the historical period affected the number of adults surviving to the upper dam. Various combinations of harvest and other sources of human-induced mortality could be combined to attempt to match historical SARs under this definition. This definition simply captures the overall survival rate through the FCRPS, lower river, and ocean that appears to be associated with an adequate level of historical survival and escapement.

Smolt-to-adult return rate to the upper dam, adjusted for harvest ("Escapement + Harvest SAR"). This definition differs from the previous definition by adding the number of harvested adults to the number of adults returning to the upper dam. A simple way of relating this definition to the first is to express it as the SAR to the upper dam (Escapement SAR), divided by (1 - the harvest rate). Because historical harvest rates were relatively high, estimates resulting from this "Escapement + Harvest SAR" definition are higher than estimates resulting from the "Escapement SAR" definition. These Escapement + Harvest SAR survival rates represent the "potential survival" of the population to the upper dam, if harvest had not occurred during the historical period. Escapement + Harvest SAR may also be thought of as representing survival to the mouth of the Columbia River during the historical period, reduced by mortality from sources other than harvest between the river mouth and the upper dam. Proponents of this definition point out that it facilitates comparison of smolt-to-adult survival rates during different time periods, when different harvest rates have been in effect.

Third, what combination of stocks should be included in the SAR estimation for a given ESU? Ideally, there should be a separate estimate of SAR for each Snake River spring/summer chinook index population that would correspond with the estimates of survival and recovery probabilities for the index population called for by both the BRWG (1994) and the jeopardy standard in the 1995 FCRPS Biological Opinion. However, this information was not available either for Snake River spring/summer chinook salmon or for the other ESUs that would be directly comparable to Snake River spring/summer chinook. Various methods for partially disaggregating this and other ESUs was discussed within the PATH subcommittee. For example, Raymond (1988) reported spring and summer components of the ESU separately, but this information is not currently available for recent years (Petrosky and Schaller 1998 - Draft Report). Although population-level indicators of the species-level biological requirements of the Snake River spring/summer chinook ESU would be desirable, the best available tool was an aggregate SAR estimate for the entire ESU.

Fourth, what are the appropriate methods and sources of data to use in estimating historical SARs according to the above definitions? There was considerable discussion among the PATH subcommittee regarding this issue and, at this time, PATH has not made a final recommendation.

Petrosky and Schaller (1998 - Draft Report) have produced preliminary estimates of both Escapement SAR and Escapement + Harvest SAR based upon Raymond's (1988) original estimates, historical harvest, and estimates of the historical age structure of naturally spawning Snake River index stocks. Preliminary estimates of the 1964 through 1969 Escapement SAR of Snake River spring/summer chinook range from 2.3% to 4.5% with a geometric mean of 2.9% (Petrosky and Schaller 1998 - Draft Report). Corresponding estimates of Escapement + Harvest SAR range from 3.7% to 7.3% with a geometric mean of 4.9%.

These SAR estimates are subject to change as PATH investigates alternate sources of data, assumptions, and methods of estimating the SARs of spring/summer chinook salmon. The NMFS urges great caution in interpreting these SAR estimates as absolute survival targets. Several concerns regarding the methods and assumptions employed in both Raymond (1988) and Petrosky and Schaller (1998-Draft Report) have been articulated by Paulsen and Giorgi (1998) and Williams (1998). Of particular concern are changes in the field sampling and analytical methods between historical and recent periods (Paulsen and Giorgi 1998), the significance of which are poorly understood at present. Some of these concerns can be addressed through sensitivity analyses (e.g., Petrosky 1998a) and some have been disputed by other PATH members (Petrosky et al. 1998). In short, several issues require further evaluation and discussion before a final PATH recommendation regarding use of any specific SAR as a proxy for survival and recovery standards can be developed. However, because most of the concerns, especially those relating to inconsistencies between historical and recent SAR estimates, appear to have similar effects on both steelhead and chinook SARs, it is unlikely that further PATH discussions will invalidate the use of these SARs for the <u>relative</u> comparisons between the two species described in Section V.D.2 and applied in this Supplemental FCRPS Biological Opinion.

Given that historical Snake River spring/summer chinook SARs can be used as a proxy for acceptable probabilities of being above population threshold levels and reaching recovery levels within a reasonable period of time, it is reasonable to assume that the same approach can be applied to other listed species. It is possible to estimate historical SARs for Snake River steelhead using comparable methods. Examination of Figure 4 in Raymond (1988) and Figure 1 in Petrosky and Schaller (1998 - Draft Report) suggests that, while some estimates indicate that wild Snake River steelhead survival may have begun to decline prior to the 1970 smolt outmigration, a declining trend had clearly begun by 1970. The PATH subcommittee considered it reasonable to define the relevant historical period as 1964 through 1969, the same as that defined for Snake River spring/summer chinook salmon, although the choice of this specific time period was less obvious for Snake River steelhead.

There was some discussion of the appropriate level of aggregation of populations within this ESU. The State of Idaho commented that Snake River steelhead "A-run" and "B-run" components should be separated in SAR analyses. However, (1) this information was not available for this Supplemental FCRPS Biological Opinion (Petrosky 1998b - Draft Report); (2) there is some confusion about the exact definition and the biological significance of "A-run" and "B-run" designations (Busby et al. 1996); and (3) it is not clear what grouping of Snake River spring/summer chinook populations would be compared with these groupings of Snake River steelhead. As stated previously, NMFS would prefer to evaluate species-level biological requirements on a population-by-population basis. However, for the purposes of the analysis in this Supplemental FCRPS Biological Opinion, the limitations of the information available at the present time dictate that Snake River steelhead SARs represent an aggregate for the entire ESU.

Preliminary estimates of Escapement SAR for Snake River steelhead during 1964 through 1969 range from 3.4% to 4.2% with a geometric mean of 3.8% (Table 9 in Petrosky and Schaller 1998 - Draft Report, based on data in Petrosky 1998b - Draft Report). Corresponding estimates for the Escapement + Harvest SAR definition range from 4.5% to 6.4% with a geometric mean of 5.6%. These estimates are subject to change and are subject to caveats similar to those described for Snake River spring/summer chinook SARs.

These results will be reviewed following completion of the PATH analysis or draft recovery planning process. If new information suggests that the above description of species-level biological requirements for Snake River steelhead is inadequate, reinitiation of consultation may be necessary.

V.A.2.b. Upper Columbia River Steelhead

The same constraints to the analytical process for identifying Snake River steelhead species-level biological requirements apply to the identification of Upper Columbia River steelhead biological requirements.

An interim approach, using the SAR methodology described in Section V.A.2.a, is currently being applied to Upper Columbia River steelhead. In the case of Upper Columbia River steelhead, it is nearly impossible to define a point at which historical survival rates decline rapidly, based on available estimates. Rather, it appears that there has been a fairly continuous decline from the time of first available smolt-to-adult survival estimates (1962 smolt year) through at least the mid-1970's (e.g., Figure 3 in Raymond 1988 and Cooney 1998 - Draft Memorandum). This suggests that, if there was a historical period characterized by high survival rates, followed by a sharp decline, as observed for Snake River spring/summer chinook salmon, that time period must have occurred prior to 1962. Absent an ability to distinguish a break in survival rates similar to that observed for Snake River spring/summer chinook salmon or to derive estimates prior to 1962, the five earliest available years (1962 through 1966) were chosen to represent the historical period for necessary Upper Columbia River steelhead SARs.

There was little discussion of methods of disaggregating estimates because available information for this ESU was sparse. Upper Columbia River steelhead SARs represent an aggregate for the entire ESU. Preliminary estimates for 1962 through 1966 Upper Columbia River steelhead Escapement SAR range from 1.7% to 2.9% with a geometric mean of 2.2% (Cooney 1998 - Draft Memorandum). Corresponding estimates for the Escapement + Harvest SAR range from 2.5%

to 4.4% with a geometric mean of 3.4%. These estimates are subject to change and are subject to similar caveats as those described for Snake River steelhead SARs

Following completion of the PATH analysis or draft recovery planning process, results will be reviewed and, if the new information suggests that the above description of species-level biological requirements for Upper Columbia River steelhead is inadequate, reinitiation of consultation may be necessary.

V.A.2.c. Lower Columbia River Steelhead

The same constraints to identifying Snake River steelhead species-level biological requirements apply to identification of Upper Columbia River steelhead.

At this time, a quantitative approach has not been defined by NMFS or PATH scientists and a quantitative definition of Lower Columbia River steelhead species-level requirements is not available for use in this Supplemental FCRPS Biological Opinion. Qualitative factors, such as the relative significance of FCRPS mortality to this ESU, compared to other ESUs, appear to be the only available option at this time.

Following completion of the PATH analysis or draft recovery planning process, results will be reviewed and, if the new information suggests that quantitative definition of species-level biological requirements for Lower Columbia River steelhead is possible, reinitiation of consultation may be necessary.

V.B. Relevance of the Environmental Baseline to the Species' Current Status

The biological requirements of Snake River steelhead, Upper Columbia River steelhead, and Lower Columbia River steelhead are currently not being met under the environmental baseline, which is apparent from the species' declining status in recent years (Busby et al. 1996). This trend was based on adult returns through 1994, which means it was based on juvenile migrations through about 1992. Updated information through the 1996 adult returns (approximately corresponding to the 1994 juvenile migration) indicates that the declining trend has continued and the environmental baseline is still detrimental (West Coast Steelhead Biological Review Team 1997; Schiewe 1997a). Maintenance or further degradation of these conditions would not reverse the declining trend and thus continue to increase the amount of risk from adverse effects the listed salmon face under the environmental baseline.

Continuing FCRPS actions initiated in the lower Columbia River projects in response to consultations for the Snake River listed stocks are expected to work toward slowing down this trend toward extinction for the steelhead stocks considered in this consultation. The benefits of these actions, however, are not yet apparent for these stocks.

V.C. Determining the Effects of the Proposed or Continuing Actions on Listed Species

Mortality and sublethal effects (e.g., changes in migration timing or speed) associated with water management, river impoundment, dam passage, transportation, and other aspects of FCRPS operation are described in Section VI. That section also describes how these effects are expected to change over time with full implementation of the RPA.

V.D. Likelihood That the Species Can Be Expected to Survive With an Adequate Potential for Recovery Under the Effects of the Proposed or Continuing Action, the Environmental Baseline and Any Cumulative Effects, and Considering Measures for Survival and Recovery Specific to Other Life Stages

V.D.1. Determine Significance of the Aggregate Effect Upon the Particular Biological Requirements of the Listed Species in the Action Area

V.D.1.a. Snake River Steelhead

Because Snake River steelhead action-area biological requirements are assumed to be equivalent to Snake River chinook action-area biological requirements (Section V.A.1.a.) and because the proposed action already has been determined not to jeopardize listed Snake River chinook salmon, those action-area requirements will be considered to be satisfied if mortality and sublethal effects on steelhead caused by operation of the FCRPS under the proposed action are less than or equal to those experienced by Snake River chinook.

In making this determination, NMFS must consider each element of the RPA to ensure that Snake River steelhead receive, at a minimum, the same protection afforded to Snake River spring/summer chinook salmon under the RPA. The RPA relies upon:

(1) <u>interim actions</u>, intended to provide for "implementation of all reasonable measures for the operation and configuration of the FCRPS that will reduce the mortalities of listed fish" (1995 FCRPS Biological Opinion, p. 91) and studies to make the best choice regarding the long-term action; and

(2) <u>long-term actions</u> that include "major structural improvements to the FCRPS that result in significant survival improvements" (1995 FCRPS Biological Opinion, p. 128).

The 1995 FCRPS Biological Opinion recognized that the interim action, if carried out indefinitely into the future, would jeopardize Snake River salmon and that, therefore, a long-term action which further reduces FCRPS-caused mortality was required for survival and recovery of the species. That 1995 RPA determined that there were several alternative long-term actions, any one of which would avoid jeopardy depending upon respective supporting assumptions.

Until the best long-term action is chosen and implemented, the interim action "aggressively pursues improvements in survivals of both inriver migrants and transported fish" to keep the status of the listed species from deteriorating further before the long-term action is implemented.

The interim actions adopted in 1995 must be reviewed with respect to relative survival of Snake River steelhead compared to survival of Snake River spring/summer chinook salmon. Particular questions include:

(1) for each interim measure in the RPA, as written in the 1995 FCRPS Biological Opinion, does the seasonality and geographical extent of the measure provide the same reduction in FCRPS mortality to Snake River steelhead as to Snake River spring/summer chinook salmon;

(2) have the interim measures in the RPA been implemented according to the schedule and in the manner anticipated in the 1995 FCRPS Biological Opinion and, if not, are additional measures required to provide listed species with the reductions in FCRPS mortality assumed at the time the 1995 FCRPS Biological Opinion was issued;

(3) are there aspects of the Snake River steelhead life history that differ significantly from Snake River spring/summer chinook life history and therefore require protective measures, relative to FCRPS operation, that were not anticipated in the original RPA measures; and

(4) have <u>all</u> reasonable measures for the operation and configuration of the FCRPS to reduce mortalities of Snake River steelhead been included?

The suite of interim studies must also be reviewed to determine if the conclusions of those studies will provide adequate information for making a long-term configuration change that will benefit Snake River steelhead.

Regarding long-term actions, there are "two primary choices for major structural improvements at the lower Snake projects: surface collectors [with smolt transportation] and drawdowns" (1995 FCRPS Biological Opinion, p. 93). The adequacy of each long-term alternative must also be evaluated with respect to Snake River steelhead.

V.D.1.b. Upper Columbia River Steelhead

Because Upper Columbia River steelhead action-area biological requirements are assumed to be equivalent to Snake River chinook action-area biological requirements, a comparison is made among hydro-related effects on each species in Section VI, as was described for Snake River steelhead. Elements of the interim and long-term RPA must be reviewed with respect to the geographic distribution and life history of Upper Columbia River steelhead, employing the considerations described for Snake River steelhead in Section V.D.1.a.

V.D.1.c. Lower Columbia River Steelhead

Because Lower Columbia River steelhead action-area biological requirements are assumed to be equivalent to Snake River chinook action-area biological requirements, a comparison is made among hydro-related effects on each species in Section VI, as was described for Snake River steelhead. Elements of the interim and long-term RPA must be reviewed with respect to the geographic distribution and life history of Lower Columbia River steelhead, employing the considerations described for Snake River steelhead in Section V.D.1.a.

V.D.2. Effects of the Proposed Or Continuing Action in the Context of the Full Life Cycle to Determine If Species-Level Biological Requirements Are Likely to Be Met

V.D.2.a. Snake River Steelhead and Upper Columbia River Steelhead

The 1995 FCRPS Biological Opinion applied quantitative analytical techniques developed and implemented by a multi-agency technical group to assess whether operation of the FCRPS would satisfy species-level biological requirements. Development of the analytical methods (risk analysis framework) and tools (e.g., run reconstructions and simulation models) took several years. Analogous tools for comprehensive evaluation of species-level biological requirements are currently not available for Snake River steelhead.

A comprehensive modeling analysis of Snake River steelhead is currently planned by the multi-agency PATH group and an analysis of Upper Columbia steelhead may also be added. A preliminary version of this analysis will be available in late 1998 and a more complete analysis should be available in 1999.

Until the PATH analysis is available, a simpler technique must be employed for assessing the impact of proposed hydro actions (in combination with other actions) on the likelihood that Snake River steelhead and Upper Columbia River steelhead will survive and recover. This simpler analysis, which is being coordinated with PATH, provides an indication of the ability to meet species-level biological requirements defined in Section V.A.2. when the proposed action is fully implemented.

Likelihood That Necessary SAR Will Be Met Under the Proposed Action The interim approach defines the incremental change in survival necessary for current Snake River steelhead SARs to reach acceptable historical SAR levels, and compares that to the incremental change necessary for Snake River spring/summer chinook salmon to reach acceptable historical SARs. Assumptions of this method are as follows:

The first assumption is that the smolt-to-adult return rates (SAR) of Snake River spring/summer chinook, Snake River steelhead, and Upper Columbia River steelhead during a historical period correspond to survival rates that represent acceptable probabilities of survival and recovery, as described in Section V.A.2. The assumption that historical SAR rates can be used as a proxy for acceptable probabilities of survival and recovery has been partially validated for Snake River spring/summer chinook salmon by PATH (Marmorek and Peters 1998 - Draft Report). However, this assumption has not been validated for steelhead.

A second assumption of this methodology is that, because the proposed action (including long-term measures, assumptions about survival changes in other parts of the life cycle, and assumptions about climate variability) has been determined not to jeopardize Snake River spring/summer chinook salmon (i.e., to result in acceptable probabilities of survival and recovery), the proposed action can be assumed to result in a survival change sufficient to bring recent Snake River spring/summer chinook SARs to the necessary historical SAR levels. The NMFS intends to reconsider this assumption after further analyses are completed for the decision on the appropriate long-term action for the FCRPS in late 1999.

The third assumption of this methodology is that the incremental change between current and historical Snake River and Upper Columbia River steelhead SAR levels is equal to or less than the incremental change necessary for Snake River spring/summer chinook salmon. This assumption is evaluated in Section VI.A.4 using techniques developed by a subcommittee of PATH. If this third assumption is correct, then the proposed action is likely to result in achievement of necessary historical SARs for Snake River and Upper Columbia River steelhead (i.e., not jeopardize steelhead) if the change in survival within the action area is the same or greater for steelhead, compared to chinook (as discussed in VIII.A.1). Conversely, if the incremental change between recent and historical steelhead SARs is greater than the incremental change needed by chinook, the proposed action will have to result in a greater increase in steelhead survival within the action area, compared to the increase in chinook survival.

V.D.2.b Lower Columbia River Steelhead

It has not been possible to develop an interim method for evaluating the effect of the proposed action on species-level biological requirements of Lower Columbia River steelhead. This assessment will be based on qualitative considerations, as discussed in Section V.A.2.c. One of the qualitative considerations is the extent to which FCRPS-related mortality has contributed to the declining status of this ESU. Factors for the decline of this ESU include hydropower effects, but the relative importance of FCRPS-related mortality compared to other sources of mortality is not specified (NMFS 1996). Qualitatively, this effect appears to be relatively small because most populations within the ESU spawn downstream of all FCRPS projects and the two populations that spawn upstream must pass only one project. Therefore, it is unlikely the FCRPS has contributed as significantly to the decline of the Lower Columbia River steelhead ESU as it has to the decline of other ESUs discussed in this Supplemental FCRPS Biological Opinion, including Snake River spring/summer chinook salmon. Proportional reductions in FCRPS-related mortality for the Lower Columbia River steelhead ESU may have a more limited effect on improving the environmental baseline for this species than for other ESUs discussed in this

Supplemental FCRPS Biological Opinion and it may not be possible to ensure that the proposed FCRPS actions will ensure survival and recovery without more detailed information regarding reductions in other sources of mortality.

V.E. Reasonable and Prudent Alternatives to a Proposed Or Continuing Action That is Likely to Jeopardize the Continued Existence of the Listed Species

This step is relevant only when the conclusion of the previously-described analysis is that the proposed action will jeopardize listed species. The reasonable and prudent alternative will have to reduce mortality associated with the proposed action to a level that does not jeopardize the species. An analysis to determine sufficiency of the reasonable and prudent alternative will be based on the same considerations described above.

VI. ANALYSIS OF EFFECTS

VI.A. Effects of Proposed FCRPS Operation by Action Agencies (Corps, BPA, BOR)

VI.A.1. Effect of Water Regulation and Impoundment of Mainstem Free-Flowing River Sections

VI.A.1.a Effects of Water Regulation and Impoundment With Respect to Biological Requirements Within the Action Area

The physical effects of water regulation and impoundment are well known (e.g., NRC 1995, NMFS 1995a; ISG 1996) and can be related to the biological requirements of steelhead in the migration corridor (Section V). Water regulation by the Action Agencies results in modification of the natural hydrograph and affects listed steelhead between upriver storage reservoirs and the ocean area influenced by Columbia River plume. Water regulation reduces flows (water quantity per unit time) that would naturally occur in the spring and this in turn reduces water velocity. Water velocity is further reduced by impoundment of mainstem river sections, which increases volume and cross sectional area, forming reservoirs from formerly free-flowing river sections. Snake River steelhead must pass through eight federal impoundments, Upper Columbia steelhead must pass through four (plus up to five additional non-federal impoundments), and Lower Columbia River steelhead must pass through one. Water regulation and impoundment also change water quality factors such as temperature (increased due to mass heat storage) and turbidity (decreased), as well as salmonid prey production (which changes from riverine aquatic insects to lacustrine planktonic organisms). Channel complexity is also reduced in reservoirs, which affects complexity of fluid dynamics (e.g., ISG 1996) and substrate type.

Slower water velocity is associated with a reduction in juvenile steelhead migration speed (e.g., Berggren and Filardo 1993; Buettner and Brimmer 1995; Giorgi et al. 1997) and an increase in adult steelhead migration speed during active migration seasons (e.g., reviews in Bjornn and Peery 1992 and Chapman et al. 1994). A slower juvenile migration rate may result in arrival at the estuary at a time or under conditions in which the species did not evolve, which could influence survival. Impoundment has created low-velocity habitats for predators (e.g., Faler et al. 1988; Mesa and Olson 1993), higher water temperatures have increased predation rates (e.g., Vigg and Burley 1991), and slower fish migration speeds (and the concentration of fish at dams - see Section V.A.3) have presumably increased the exposure of juvenile steelhead to predation. The lack of natural complexity within the migration corridor and the shift in juvenile prey associated with lacustrine habitat may also affect juvenile steelhead survival (ISG 1996). These and other potential causal relationships (see ISG 1996, Fig. 6.1) suggest that juvenile steelhead survival is reduced by impoundments and low flows caused by federal water regulation. This conclusion is supported by Petrosky (1998b - Draft Report), who demonstrated an association between smolt-to-adult survival of Snake River steelhead and combined Snake and Columbia River flows (expressed as fish travel time from Lower Granite pool to Bonneville Dam).

VI.A.1.b. Reduction of Adverse Effects of Water Regulation and Impoundment Through Proposed Measures

VI.A.1.b.1) Reduction of Adverse Effects of Water Regulation and Impoundment Through Flow Augmentation

Interim Measures in the 1995 RPA Flow augmentation is a special case of water regulation, in which the primary purpose of releases from storage reservoirs is to aid salmonid migration, rather than to generate power. Interim period releases are timed to coincide with juvenile salmon and steelhead migration periods, as determined inseason by the Technical Management Team, without drafting storage reservoirs below levels that would likely reduce available water in subsequent years (1995 RPA Measure 1). For both Snake River steelhead and Lower Columbia River steelhead, flow augmentation during the interim period (i.e., the spring flow objectives at Lower Granite and McNary Dams, as described in 1995 RPA Measure 1) is designed to partially mitigate the effects of federal water regulation and impoundments.

Long-Term Measures in the 1995 RPA The long-term flow augmentation actions include identifying and providing additional volumes of water for flow augmentation from the upper Snake River (1995 RPA Measure 1[b]) and Canada (1995 RPA Measure 1[d]). Studies to determine the most effective use of available water are also required (e.g., flow "pulsing" evaluation [1995 RPA Measure 13(g)], and various flow/survival studies [1995 RPA Measures 13© and 13(f)]).

Supplemental Proposed Action As described in Section III, the proposed action includes adoption of a mid-Columbia flow objective of 135 kcfs from April 10 to June 30 and various specific measures, including a shift in flood control timing, to increase the likelihood that the flow objective can be met. Details regarding the flow objective are included in Appendix A. The purpose of this supplemental proposed action is to provide Upper Columbia River steelhead with similar reductions in mortality associated with water regulation, as those afforded to Snake River spring/summer chinook salmon through the Lower Granite and McNary flow objectives specified in the 1995 RPA. Additionally, 1995 RPA Measure 1(g) is revised to shift the planning date for the start of Snake River flow augmentation from April 10 to April 3 to reflect the earlier migration timing of Snake River steelhead.

VI.A.1.b.2) Reduction of Adverse Effect of Water Regulation and Impoundment by Lowering Reservoir Elevations

Interim Measures in the 1995 RPA Because reducing the cross-sectional area of a reservoir is equivalent (from the standpoint of average water velocity) to increasing the flow, reduction of Snake River run-of-river reservoir elevations to within one foot of the minimum elevations authorized for each project (minimum operating pool [MOP]) could partially mitigate the impacts of impoundment during interim operations (1995 RPA Measure 4). Additionally, the Action Agencies were directed to investigate reducing the elevation of John Day pool to within three feet of MOP during the juvenile migration period (1995 RPA Measure 5).

Long-Term Measures in the 1995 RPA The Action Agencies were directed to complete necessary feasibility and design work to prepare for drawdown of Snake River reservoirs to spillway crest or natural river level, to begin by 2000 (1995 RPA Measure 10). Spillway crest drawdowns could potentially reduce adverse effects of water management and impoundment, while natural river drawdowns would additionally reduce adverse effects of migration barriers (see Section VI.A.3).

Supplemental Proposed Action As described in Section III, the proposed action includes a feasibility study to determine the long-term action for lower Columbia River projects. This study will consider possible natural river drawdowns of John Day and/or McNary Reservoirs. The principal purpose of this supplemental proposed action is to provide long-term measures for Upper Columbia steelhead that parallel those included in the 1995 RPA for Snake River spring/summer chinook salmon. Effects on listed Snake River populations will also be considered as will those on other fish and wildlife species throughout the Columbia River basin.

VI.A.1.b.3) Reduction of Adverse Effect of Water Regulation and Impoundment by Predator Removal

Interim and Long-Term Measures in the 1995 RPA Continued evaluation of predator removal to reduce reservoir predation was required by 1995 RPA Measure 14 to partially mitigate the effect of impoundments in creating low-velocity predator habitat and the effect of dams in concentrating juvenile smolts, making them more susceptible to predation. Additionally, the Action Agencies were directed to study effects of bird predation and ways to reduce it (Incidental Take Statement term and condition number 9 [IT 9]).

VI.A.1.b.4) Reduction of Adverse Effect of Water Regulation and Impoundment by Temperature Regulation

Interim and Long-Term Measures in the 1995 RPA IT 17 called for monitoring river temperatures and implementing, when possible, temperature control measures in the lower Snake River -- such as releasing cool water from Dworshak Dam and the Hells Canyon complex. Measures were also required to alleviate warm temperatures in the McNary Dam juvenile fish facility (IT 5) and in adult fish ladders at various projects (IT 18).

VI.A.1.c. Relative Effect of Water Regulation and Impoundment, and Measures to Reduce Associated Mortality, on Listed Steelhead and Snake River Chinook Salmon

VI.A.1.c.1) Juveniles

Reservoir Survival The factors considered in Section VI.A.1 primarily effect reservoir survival of juveniles. Reservoir-specific estimates of survival are not available for either chinook salmon or steelhead. Reach survival estimates, which include effects of dams in addition to effects of water regulation and impounded reservoirs, are described in Section VI.A.3. The efficacy of flow augmentation and lowered reservoir elevations can be evaluated by looking at the strength of the association between flow and migration speed or reach survival for each species.

Migration Speed Migration speed of steelhead at a given flow is generally greater in steelhead than in yearling chinook salmon, suggesting that exposure time to predation may be lower in steelhead and estuary arrival timing may be closer to that under which the species evolved (Table VI-1). Migration speed is positively correlated with flow for Snake River steelhead and Upper Columbia River steelhead, as reviewed in Appendix A. Information specific to Lower Columbia River steelhead is not available.

Flow versus Survival the efficacy of flow augmentation and/or lowering reservoir elevations (which also increases water velocity) in reducing Snake River steelhead mortality is very similar to the efficacy of flow augmentation for reducing Snake River spring/summer chinook mortality. Regression of reach survival of primary release groups between Lower Granite Reservoir and Lower Monumental Dam for 1994 through 1996 on flow was highly significant for each species, with comparable predictive power ($R^2 = 0.65$ for yearling chinook and $R^2 = 0.52$ for steelhead; Smith et al. 1998). The slopes of the regression lines also were nearly identical (0.0040 for chinook and 0.0038 for steelhead), suggesting a similar association between flow and survival in the two species. Regressions of the survival of daily release groups between Lower Granite Dam and Lower Monumental Dam for 1994 through 1996 against flow also were highly significant and very similar for the two species, although the predictive power of the regressions was poor ($R^2 = 0.18$ for chinook and $R^2 = 0.17$ for steelhead). A relationship between flow and survival within years was not detected for either species (Smith et al. 1998).

Similar information regarding reach survival versus flow is not available for Upper Columbia River steelhead and Lower Columbia River steelhead. It is likely that Upper Columbia River steelhead reach survival is affected by flow regulation in a similar manner to Snake River steelhead. However, applicability of this information to Lower Columbia River steelhead, which pass no more than one dam during emigration, is unknown.

Table VI-1. Comparison of migration speed of yearling chinook and steelhead in the Snake and Columbia Rivers, from bivariate flow:travel time relationships. Flows of 85 to 100 kcfs are examined because these correspond to the spring Snake River flow objectives to which Snake River chinook are exposed. Closest flows to 85 to 100 are examined in the mid-Columbia to indicate similar flows for Upper Columbia steelhead. Studies in Bonneville pool that would be relevant to Lower Columbia steelhead are not available.

Flow and Location	Migration Speed of Yearling Chinook	Migration Speed of Steelhead	Study
85-100 kcfs Lower Granite Dam to McNary Dam	11.6-12.7 mi/day (hatchery)	13.6-16.2 mi/day (hatchery)	Berggren and Filardo (1993)
85-100 kcfs Lower Granite Dam to Lower Monumental Dam	7.2-7.6 mi/day (hatchery)	7.4-9.2 mi/day (hatchery)	Smith et al. (1998) - SH range includes annual variability 1994-96
85-100; 110-130 kcfs Rock Island Dam to McNary Dam	11.0-11.8 mi/day at 85-100; 12.3-13.2 mi/day at 110-130 (Mixed)	14.2-16.0 mi/day at 85-100; 17.2-19.6 mi/day at 110-130 (Wild)	Giorgi et al. (1997)
85-100; 110-130 kcfs Methow River to McNary Dam	9.0-9.1 mi/day at 85-100; 9.1 mi/day at 110-130 (Hatchery)	12.0-13.8 mi/day at 85-100; 13.7-14.8 mi/day at 110-130 (Hatchery)	Berggren and Filardo (1993)

Average flow during the outmigration can also be compared to smolt-to-adult returns to evaluate the effect of flow on survival. Caveats regarding application of this approach to determining effects of the FCRPS on survival are explained in Appendix A. A significant relationship between SAR and average flow during juvenile Snake River spring/summer chinook salmon emigration was reviewed in NMFS (1995b). Similarly, Petrosky (1998b - Draft Report) reported a significant ($P < 0.001$; $r^2 = 0.37$) negative relationship between Lewiston-to-Bonneville fish travel time, which is a function of flow, and 1964 through 1993 estimates of wild Snake River steelhead SARs. Appendix A includes summaries of three time series of estimated SARs of wild and hatchery Upper Columbia River steelhead (in some cases, mixed with Middle Columbia River steelhead) and compares them with average flow conditions during smolt migration. In each case, SARs were generally higher when mean flows were higher and SARs were lower when mean flows were lower, although a statistically significant relationship could be detected for only one data set. Similar flow-versus-SAR relationships are not available for Lower Columbia River steelhead.

Migration Timing in Relation to Flow Augmentation and Reservoir Drawdowns Timing of the Snake River steelhead juvenile migration is similar to that of Snake River spring/summer chinook. Therefore, the timing of flow objectives for Snake River spring/summer chinook salmon, as described in 1995 RPA measure 1, should be sufficient to provide comparable benefits for Snake River steelhead.

A variety of observations suggesting that April 10 through June 30 are reasonable planning dates for flow objectives for Upper Columbia River steelhead are cited in Appendix A. The supplemental proposed action adopts these planning dates in defining mid-Columbia flow objectives.

Because Lower Columbia River steelhead migrate through, at most, one reservoir and dam, flow objectives have not been specifically defined for this species, nor have planning dates for flow augmentation. The limited information available suggests that the McNary flow objectives and planning dates described in 1995 RPA Measure 1 should be sufficient for the lower Columbia River steelhead ESU.

Predation Limited information on predation rates in John Day Reservoir suggests that predators such as squawfish and smallmouth bass cause a higher mortality rate for juvenile steelhead (mixture of Snake River, Upper Columbia River, and Middle Columbia River steelhead) than for juvenile yearling chinook (Table VI-2). If the observations in John Day Reservoir are applicable to other reservoirs, removal of a given number of squawfish should reduce the steelhead predation rate more than the yearling chinook predation rate. (For example, Table VI-2 suggests that if half of the predators could be removed in April, steelhead mortality in John Day Reservoir for that month would presumably be reduced six percent while yearling chinook mortality would be reduced four percent).

Table VI-2. Estimated mortality of juvenile salmon and steelhead from predation by month in John Day Reservoir, 1983 through 1986. Predators considered were northern squawfish (Ptychocheilus oregonensis), walleye (Stizostedion vitreum), and smallmouth bass (Micropterus dolomieu). During April and May virtually all chinook salmon are yearling chinook salmon, based on McNary Dam smolt monitoring. During July, chinook salmon are a mixture of yearlings and subyearlings, so this the reported mortality rate is greater than the yearling chinook mortality rate. (From Table 6 in Reiman et al. 1991).

Month	Steelhead		Chinook Salmon	
	Mortality Rate	Standard Deviation	Mortality Rate	Standard Deviation
April	0.12	0.061	0.08	0.034
May	0.11	0.031	0.11	0.017
June	0.13	0.089	0.07	0.025

VI.A.1.c.2) Adults

Temperature Control Technical Management Team decisions through 1995 RPA Measure 1(g) and improved water conditions during the past four years have resulted in reduced summer temperatures in the lower Snake River. Since 1995 water temperatures, measured in the scroll cases at Ice Harbor Dam, have not exceeded 70° F (Biological Assessment, Section 4.3.2.1). However, the water temperature standard of 68° F for the lower Snake and Columbia Rivers is still not being met.

The peak of migration of adult Snake River steelhead generally occurs earlier than that of Snake River fall chinook. Although a larger proportion of the steelhead may be exposed to higher temperatures, it is likely that both species benefit from late summer water management. Because summer temperatures in the upper Columbia River are often substantially lower than those in the Snake River (Corps, Annual Fish Passage Reports), Upper Columbia River steelhead are exposed to high temperatures for a shorter time than are Snake River steelhead. Lower Columbia River steelhead, which migrate shorter distances in the Columbia River, should be even less affected by high mainstem temperatures.

VI.A.2. Barriers to Migration

VI.A.2.a Effects of Barriers to Migration With Respect to Biological Requirements Within the Action Area

Presence of dams results in some migrational delay, thereby influencing migration speed and timing of both adults and juveniles. Additionally, dams impede safe passage of juveniles and, to a lesser extent, adults. Some juvenile mortality is associated with all routes of passage at dams, with highest mortality occurring through turbines (e.g., reviewed in Whitney et al. 1997). Some passage routes have additional effects, such as the increase in total dissolved gas (water quality) caused by high spill levels.

For Snake River steelhead, operation of the eight Snake and Lower Columbia river dams is included in the proposed action. For Upper Columbia River steelhead, operation of the four lower Columbia River dams is included in the proposed action. For Lower Columbia steelhead, only Bonneville Dam operation is included.

VI.A.2.b. Reduction of Adverse Effects of Barriers to Migration Through Proposed Measures

VI.A.2.b.1) Reduction of Adverse Effects of Barriers to Migration Through Spill

Interim Measures in the 1995 RPA Because mortality associated with juvenile passage via the spillway is very low (e.g., zero to two percent, based on review of 13 studies by Whitney et al. 1997), minimum spill levels were established at all projects to reduce the proportion of smolts passing through turbines (1995 RPA Measure 2). To allow higher spill levels without causing detrimental effects of high total dissolved gas (TDG) levels, gas abatement studies and implementation of specific measures such as spill deflectors at Ice Harbor and John Day Dams were required (1995 RPA Measure 18). Additionally, physical and biological monitoring of TDG effects was required (1995 RPA Measure 16).

Long-Term Measures in the 1995 RPA Studies to examine methods of more effectively attracting surface-oriented juveniles to the spillway were required (1995 RPA Measure 11), with the intention of implementing new designs in the future if tests are successful. In addition to specifying interim period gas abatement measures such as spill deflectors, 1995 RPA Measure 18 also required studies to identify long-term gas abatement measures such as tailrace modifications.

Supplemental Proposed Action As described in Section III, the proposed action includes spill additional to that required by 1995 RPA Measure 2 at some projects in order to improve survival for inriver migrants. Details are included in Appendix C. This includes the following modifications to 1995 RPA Measure 2: (1) spill that results in greater than 80% fish passage efficiency (i.e., the proportion of fish passing the project through non-turbine routes) is required at some projects; and (2) the initial planning date for Snake River spill is changed from April 10 to April 3 to reflect the earlier timing of Snake River steelhead.

VI.A.2.b.2) Reduction of Adverse Effect of Barriers to Migration Through Juvenile Bypasses

Interim Measures in the 1995 RPA Juvenile bypasses divert a proportion of the juveniles approaching turbine intakes into channels that route fish into holding areas for transportation or else route fish back to the river downstream of the dam. A number of elements of the reasonable and prudent alternative were implemented in an attempt to make this mitigation feature more effective. Some specific measures include: install extended-length screens at three projects to improve guidance into the bypasses (1995 RPA Measures 19 and 21) and relocate bypass outfalls at Bonneville Dam (1995 RPA Measure 23 -- the outfall at the Second Powerhouse will be completed by 1999 but the First Powerhouse outfall will not [Biological Assessment, Section 4.7.11]). Several other interim measures called for in the 1995 RPA have been deferred until after 1999.

Long-Term Measures in the 1995 RPA Long-term measures include: investigate methods of bypassing surface-oriented juveniles, before they dive and approach turbine intakes (1995 RPA Measure 11); improve guidance at Bonneville Dam above current levels (1995 RPA Measure 12); conduct studies to improve existing bypasses such that at least 80% of juveniles pass via non-turbine routes and have at least 95% survival (1995 RPA Measure 15); improve the bypass and associated fish facility at Lower Granite Dam (1995 RPA Measure 20 - although this action was originally specified as interim, it has now been deferred until after 1999 [Biological Assessment, Section 4.7.8]); and design a juvenile bypass system for The Dalles Dam (1995 RPA Measure 24 - completion by 1999 is dependent upon results of prototype surface bypass/collector tests in 1998 [Biological Assessment, Section 4.7.12]).

VI.A.2b.3). Reduction of Adverse Effect of Barriers to Migration Through Turbine Operations

Interim Measures Passage through turbines is the route that causes highest juvenile mortality (e.g., review in Whitney et al. 1997; Muir et al. 1997) as well as adult fallback mortality (Wagner and Ingram 1973). Therefore, most measures to partially mitigate effects of dams attempt to pass juveniles through other routes, as described above. One method of reducing the mortality of those juveniles that do pass through turbines is to operate turbines near peak efficiency. The 1995 RPA Measure 6 requires that this occur during the salmon passage season.

VI.A.2.b.4) Reduction of Adverse Effect of Barriers to Migration Through Adult Fishways and Extended Operation of Juvenile Bypasses to Reduce Adult Fallback

Interim Measures Ladders designed to reduce delay and facilitate adult passage are in place at all dams. Measures to improve the effectiveness of adult fishways include maintaining ladders in criteria for optimal fish passage during the passage season (1995 RPA Measure 7) and maintaining spare parts and back-up systems sufficient to ensure their proper operation (IT 15 and IT 16). Additionally, juvenile fish facilities are operated longer than necessary for juveniles, in order to protect adults from falling back at a project through turbines (1995 RPA Measure 8).

VI.A.2.c. Comparison of Effects for Listed Steelhead and Snake River Chinook Salmon

VI.A.2.c.1) Juveniles of All Species

Turbine Survival Turbine survival studies published through 1990 at Snake and lower Columbia River dams have been reviewed by Iwamoto and Williams (1993). The Independent Scientific Group (ISG 1996) and Whitney et al. (1997) reviewed studies published through 1995, including several from mid-Columbia projects. At least one other turbine survival study has been conducted since that time (Normandeau Associates and Skalski 1997).

Turbine mortality has been estimated primarily for juvenile salmon, although at least two studies have estimated steelhead mortality (Weitkamp et al. 1980; Olson and Kaczynski 1980). Estimates of turbine mortality vary greatly among studies, ranging from 2.3% to 19%. Whitney et al. (1997) pointed out that studies that recovered marked fish in the tailrace very quickly using radio-tags resulted in estimates of seven percent mortality or less (average 5.5%). Results of Normandeau Associates and Skalski (1997), not reviewed by Whitney et al. (1997), fit into this category as well. Other studies with longer times between turbine passage and recovery averaged 10.9% mortality. Whitney et al. (1997) suggested that the lower estimates most likely estimate mortality directly associated with turbine passage while the others probably include factors beyond the turbine, such as predation of disoriented smolts.

With only two estimates of steelhead turbine mortality among the more than 20 estimates for salmon, it is not possible to determine whether survival rates differ between species. The range of estimates in the steelhead studies (3% to 16%) is similar to the range in chinook studies (2.3% to 19%), but may be more closely related to the type of turbine involved. The steelhead estimate for passage through Kaplan turbines, using a “long” recovery period technique, was 16%. This mortality rate is similar to the level observed in the majority of the “long” recovery chinook studies, most of which involved passage through Kaplan turbines. The steelhead mortality estimate for passage through bulb turbines was three percent, directly comparable to a mortality estimate of seven percent for coho salmon in the same study.

In summary, it is unlikely that turbine survival rates of steelhead are different from those for yearling chinook salmon. The 1995 RPA measures designed either to (1) route juvenile migrants to bypasses or spillways or (2) reduce impacts by operating turbines at peak efficiency are unlikely to affect steelhead differently than chinook, although this statement cannot be documented with the information available.

<u>Spill Survival</u> Whitney et al. (1997) reviewed 13 estimates of spill mortality (3 steelhead and 10 salmon) published through 1995 and concluded that zero to two percent is the most likely range for standard spill bays. However, they also pointed out that local conditions, such as back eddies or other situations that may favor the presence of predators, may lead to higher spill mortality. In some studies reviewed by Whitney et al. (1997), point estimates for mortality in spill bays with spill deflectors were higher than estimates for spill bays without deflectors, but there were no statistical differences between the two. This also occurred in two more recent studies (Muir et al. 1997; Dawley et al. 1997), but there were significant differences between the two spillway types in another recent study (Normandeau et al. 1996) and a fourth study showed statistically significant differences at one flow rate but not at others (Mathur et al. 1997).

In general, steelhead spill survival estimates are the same as salmon spill survival estimates, since two of three available estimates are 0% to 2.2%. One exception is an estimate of 27.5% steelhead mortality associated with passage through a spill bay without a deflector at Lower Monumental Dam (Long et al. 1975). In the same study, the authors found a more normal spill mortality rate (2.2%) associated with a spillbay equipped with a deflector. The authors recognized that the "without-deflector" result was highly unusual and proposed that a condition favoring predation below the test spillway may have affected results.

Bypass Survival Direct bypass survival is defined as survival past systems including turbine intake screens, gatewells, orifices, bypass flumes, and, in some cases, dewatering screens, wet separators, sampling facilities including holding tanks, and bypass outfall conduits. Indirect bypass mortality may be associated with predation that occurs at a poorly-sited bypass outfall or delayed mortality caused by bypass passage, but expressed further downstream. A minimum estimate of mortality can be determined from observations of dead fish in sampling facilities. Table VI-3 summarizes recent yearling chinook and wild steelhead facility mortality estimates at juvenile sampling facilities in recent years. These estimates suggest that direct bypass mortality of both wild steelhead and yearling chinook is generally less than one percent and that in nearly all cases juvenile steelhead facility mortality is less than yearling chinook mortality.

No measure of indirect mortality (following outfall release) is available at most projects for juvenile steelhead. However, studies of subyearling chinook bypass mortality at Bonneville Powerhouse One and Powerhouse Two (Ledgerwood et al. 1990, 1994; Dawley et al. 1996) indicate that high bypass mortality may be associated with predation that occurs at a poorly-sited bypass outfall. There is no information to suggest that indirect mortality is higher for steelhead than for yearling chinook salmon at any projects under current conditions.

Fish Guidance Efficiency

The effectiveness of intake screens in diverting fish approaching the turbines into bypass systems is known as fish guidance efficiency. FGE differs among wild and hatchery yearling chinook salmon (Krasnow 1998 - Draft Report) but appears to be identical for wild and hatchery steelhead (S. Smith, NMFS, pers. comm. 1998), based on analysis of recent PIT-tag detection rates. For both species, there is uncertainty regarding the change in FGE occurring since the replacement of standard length traveling screens (STS) with extended-length bar screens (ESBS) at several projects (Krasnow 1998 - Draft Report; Marmorek and Peters 1998 - Draft Report). Side-by-side estimates of STS versus ESBS FGE using fyke-net recoveries indicate that FGE is considerably higher with ESBS than with STS (e.g., McComas et al. 1993; Gessel et al. 1994; Brege et al. 1994). However, this difference has not been confirmed under full operating conditions, based on PIT-tag detection rates before and after ESBS installation at Snake River projects (IDFG analysis reported in Krasnow 1998 - Draft Report). The PATH analytical group has recommended examining sensitivity to both assumptions.

Table VI-3. Percent facility mortality at juvenile fish facilities, 1993 to 1996, from Martinson et al. (1997) and Spurgeon et al. (1997).					
Dam and Year		**Yearling Chinook (Mixed)**	**Yearling Chinook (Wild)**	**Steelhead (Wild)**	**Difference (SH - CH)**
Lower Granite					
1993			0.003	<0.001	-0.002
1994			0.004	<0.001	-0.003
1995			0.002	<0.001	-0.001
1996			0.009	<0.001	-0.008
Little Goose					
1993			0.004	0.001	-0.003
1994			0.012	0.002	-0.010
1995			0.006	0.001	-0.005
1996			0.012	0.002	-0.010
Lower Monumental					
1993			0.001	0.001	0.000
1994			0.005	0.003	-0.002
1995			0.002	0.001	-0.001
1996			0.004	0.001	-0.003
Ice Harbor					
1996			0.000	0.000	0.000
McNary					
1993		0.006		0.002	-0.004
1994		0.011		0.005	-0.006
1995		0.001		<0.001	0.000
1996		0.001		0.001	0.000
Bonneville PH1					
1993		0.001		0.000	-0.001
1994		0.002		0.001	-0.001
1995		0.001		0.000	-0.001
1996		0.002		0.001	-0.001
Bonneville PH2					
1993		0.007		0.000	-0.007
1994		0.013		0.004	-0.009
1995		0.006		0.015	0.009
1996		0.005		0.005	0.000

Data in Table VI-4 show that relative guidance of steelhead and yearling chinook salmon varies by project, chinook origin, and ESBS versus STS assumption. Steelhead FGE is estimated to be 3% to 29% higher than yearling chinook FGE at all projects except McNary, The Dalles (which does not have a screened bypass system), and the Bonneville second powerhouse.

Spill Efficiency/Effectiveness

Spill effectiveness is the proportion of fish approaching a project that pass via the spillway, and spill efficiency is spill effectiveness divided by the proportion of total river flow that is passing over the spillway at the same time. Recent reviews of spill efficiency and effectiveness include Steig (1994), Giorgi (1996), Whitney et al. (1997), and Marmorek and Peters (1998 - Draft Report). Estimates of spill efficiency vary by project and, in some cases, can be described as functions of the proportion of project flow passing over the spillway. Nearly all spill efficiency studies are based on hydroacoustics, and therefore steelhead and yearling chinook efficiencies cannot be distinguished. One recent radio-telemetry study included relatively large numbers of each species, allowing seasonal-average comparisons of the proportion of fish that passed the dam by a known route (Adams et al. 1997 -- their Figure 4-12). In this study, 37% of hatchery yearling chinook, 50% of hatchery steelhead, and 47% of wild steelhead went through the spillway over the course of the study period. The distributions of release-group timings for the two species were not identical, so the two species may not have been exposed to identical distributions of spill conditions. However, these results suggest that the seasonal effectiveness of spill in passing steelhead was at least as great as that observed for yearling chinook at Lower Granite Dam during 1996.

General - Timing and Applicability of Juvenile Chinook Measures for Juvenile Steelhead

Review of Smolt Monitoring Program index data for wild Snake River steelhead arriving at Lower Granite Dam has shown that, for the period 1985 through 1997, the mean date of arrival for at least 100 fish per day is April 3 (1993 was omitted because sampling did not begin until April 15 when an index of 1,040 fish occurred). In some years wild steelhead arrive earlier than April 3 in substantial numbers (more than 2,000 fish per day 3/30/97); the migration generally commences the last week of March. Because of this discrepancy in timing, the supplemental proposed action sets a planning date for initiating spill of April 3, rather than the April 10 date in 1995 RPA Measure 2. In general, other planning dates for juvenile chinook appear to be adequate for juvenile steelhead. The end-of-season dates for spill, peak efficiency, and bypass operations are designed to protect subyearling chinook and therefore extend well past the end of the steelhead outmigration. Any unusual migration timing will be evident during inseason monitoring and protective measure start dates can be adjusted accordingly by the Technical Management Team.

Table VI-4. Estimates of fish guidance efficiency (FGE) with current project configurations, from Krasnow (1998 - Draft Report) and Smith (1998). Estimates are made for two assumptions about the effectiveness of extended-length bar screens (ESBS), relative to standard traveling screens (STS) for chinook; however, these alternative assumptions do not apply to steelhead FGE estimates, based on available PIT-tag observations (Smith 1998). Position of operating gate affects FGE, as described in Krasnow (1998 - Draft Report). ROG = raised operating gate; SOG = stored operating gate; LSTS = lowered standard traveling screen; STR = streamlined trash rack; TIE = turbine intake extension.

Dam	Current Fish Guidance Configuration/Structure	ESBS > STS				ESBS = STS				Difference (SH - Wild CH)
		Yearling Chinook			Steelhead	Yearling Chinook			Steelhead	
		Wild	Hatchery	Mixed		Wild	Hatchery	Mixed		
Lower Granite	6 of 6 turbines w/ ESBS, ROG	0.78	0.73	0.75	0.81	0.55	0.46	0.47	0.81	0.03 to 0.26
Little Goose	6 of 6 turbines w/ ESBS, ROG	0.82	0.76	0.78	0.81	0.64	0.52	0.54	0.81	0.01 to 0.17
Lower Monumental	6 of 6 turbines w/ STS, SOG	0.61	0.47	0.49	0.82	0.61	0.47	0.49	0.82	0.21
Ice Harbor	6 of 6 turbines w/ STS, ROG	0.71	0.60	0.62	0.74	0.71	0.60	0.62	0.74	0.03
McNary	14 of 14 turbines w/ ESBS, ROG	0.95	0.81	0.83	0.89	0.79	0.68	0.69	0.89	-0.06 to +0.10
John Day	16 of 16 turbines w/ STS, no OG	0.64	0.54	0.55	0.68	0.64	0.54	0.55	0.68	0.04
The Dalles	Ice and trash sluiceway w/ forebay overflow	0.46	0.39	0.40	0.40	0.46	0.39	0.40	0.40	-0.06
Bonneville I	10 of 10 units w/ STS, SOG	0.38	0.32	0.33	0.51	0.38	0.32	0.33	0.51	0.13
Bonneville II	8 of 8 units w/ LSTS, STR, alt TIE, SOG	0.44	0.37	0.38	0.39	0.44	0.37	0.38	0.39	-0.05

VI.A.2.c.2) Adults of All Species

Adult Fallback Rates and Fallback Mortality

Available information indicates high mortality for adult steelhead which fall back past dams through turbines. Mortality estimates for fallback of adult steelhead through turbines range from 22% to 57% (Buchanan and Moring 1986; Liscom et al. 1985; Wagner and Ingram 1973). The NMFS is not aware of information regarding the fallback mortality of adult chinook salmon through turbines. However, using a theoretical strike methodology to address the relationship between direct strike by a turbine blade and fish length, estimates 41% and 49% mortality for 25- and 30-inch fish (respectively) are derived, similar to those observed for adult steelhead (Scott 1985).

A substantial percentage of adult salmon and steelhead passing dams have been observed to fall back through spillways at certain dams under certain conditions (Bjornn and Peery 1992). High fallback rates are usually associated with high river flows and spill, as well as the location of fishways exits relative to the spillways. In studies in which both adult chinook and steelhead were radio-tagged, fallback rates are generally similar for both species (Table VI-5). Fallback rates ranged from 0% to 38.9% and 0% to 50% (n = 4 for the 50% estimate) for chinook and steelhead, respectively. Liscom et al. (1979) concluded from several fallback studies that fallback rates can be high at times, but few fish are injured or die as a direct result of fallback; migration times are increased if the fish must reascend the dam.

Adult Passage Mortality Cumulative passage mortality for adult steelhead migrating up the Columbia and Snake Rivers through eight mainstem dams can be substantial. One estimate of loss is calculated from the difference in adult counts between successive dams (after adjustment for legal harvest) and represents loss and mortality. Mortality can be caused by:

- effects of delayed migration,
- fallback through turbines,
- illegal harvest,
- delayed mortality from marine mammal predation,
- gas supersaturation,
- gillnet interactions, and
- disease.

Table VI-5. Estimates of adult fallback past Snake and Columbia River projects from radio-telemetry studies of both steelhead and chinook.
* = Steelhead and chinook in this study were released 1,300 feet upstream of Lower Monumental Dam.

Project	Reference	Chinook Fallback Rate	Number Tagged	Steelhead Fallback Rate	Number Tagged	Difference (SH - CH)
Bonneville	Monan and Liscom (1975)	.389 (Summer)	18	.500	4	.111
	Liscom et al. (1978) in Bjornn and Perry (1992)	.022 (Spring)	90	.000	35	-.022
	Ross (1983)	.150 (Summer/Fall)	20	.050	20	-.100
	Ross (1983)	.000 (Fall)	12	.000	14	.000
Lower Monumental*	Liscom et al. (1985) in Bjornn and Perry (1992)	.094 (Summer/Fall)	32	.202	258	.108
Little Goose*	Liscom et al. (1985) in Bjornn and Perry (1992)	.077 (Summer/Fall)	13	.038	157	-.039

Apparent adult loss between dams may also be due to factors other than mortality of adults, such as:

- counting errors,
- double-counting fish that fall back and re-ascend ladders,
- straying, and
- tributary turnoff.

The combination of these effects has led to apparent adult passage losses between Bonneville Dam and Lower Granite Dam.

Another indication of adult passage loss (which excludes counting errors, double-counting fish that ascend ladders more than once, and straying or turnoff into tributaries) is data from radio tagging studies (Bjornn et al. 1992, 1994, 1995; Turner et al. 1984b; Liscom et al. 1978; Ross 1983; Monan and Liscom 1976). Based on these studies comparing passage of both chinook and steelhead, the combined passage loss of radio-tagged fish in the lower Snake and lower Columbia Rivers (which is applicable to Snake River steelhead) is estimated to be 20.8% (79.2% survival) (Table VI-6; Ross 1998). The NMFS considers the 20.8% loss of radio-tagged Snake River steelhead to be a more representative estimate of mortality attributable to passage through the FCRPS than estimates based on dam counts. This estimate of steelhead survival (79.2%) is greater than the 74.8% survival of chinook salmon, estimated in an identical manner using information from the same studies.

The survival of adult Upper Columbia River steelhead cannot be estimated through the upper dam in the same manner because of a lack of radio-telemetry studies in the mid-Columbia River. However, survival of Upper Columbia steelhead from Bonneville Dam to McNary Dam, which constitutes most of the impounded federal reach, can be determined in the same manner as described above, using a subset of the observations. Steelhead survival averages 95.2% in these studies, compared to 88.4% survival of chinook salmon (Table VI-6; Ross 1998).

The survival of adult Lower Columbia River steelhead, for those stocks in the ESU that spawn above Bonneville Dam, can be inferred from estimates of survival past Bonneville Dam (Table VI-6; Ross 1998). Mean steelhead survival in these studies averages 96.4%, compared to 94.3% survival of chinook salmon.

<u>Mortality of Downstream-Migrating Adults (Kelts)</u>

Unlike chinook salmon, which die after spawning, steelhead may survive to spawn more than once. Adults that have spawned and are migrating back downstream to return to the ocean are referred to as “kelts.” Estimates of the number or proportion of steelhead that survive spawning

Table VI-6. Estimates of adult survival past Snake and Columbia River projects from radio-telemetry studies, as summarized in Ross (1998).

Project	Reference	Chinook Project Survival	Average Chinook Project Survival	Steelhead Project Survival	Average Steelhead Project Survival	Difference (SH - CH)
Bonneville	Turner et al. (1984)	0.900 (Fall)		0.943 (Fall)		0.043
Bonneville	Liscom et al. (1978)	1.000 (Spring)		0.925 (Summer)		-0.075
Bonneville	Ross (1983)	0.872 (Spring)		0.952 (Summer)		0.080
Bonneville	Ross (1983)	0.943 (Fall)		1.000 (Fall)		0.057
Bonneville	Monan and Liscom (1976)	1.000 (Spring)		1.000 (Fall)		
Bonneville Mean (Lower Columbia River Steelhead Total FCRPS Reach)			**0.943**		**0.964**	**0.021**
The Dalles	Liscom et al. (1978)	0.985 (Spring)		1.000 (Summer)		0.015
The Dalles	Monan and Liscom (1976)	0.946 (Spring)		1.000 (Summer)		0.054
The Dalles Mean			**0.966**		**1.000**	**0.034**
John Day	Liscom et al. (1978)	1.000 (Spring)		1.000 (Summer)		**0.000**
McNary Estimate	Ross (1998)		**0.970**		**0.988**	**0.018**

Table VI-6. Estimates of adult survival past Snake and Columbia River projects from radio-telemetry studies, as summarized in Ross (1998).

Project	Reference	Chinook Project Survival	Average Chinook Project Survival	Steelhead Project Survival	Average Steelhead Project Survival	Difference (SH - CH)
Bonneville to McNary Mean (Upper Columbia River Steelhead Total FCRPS Reach Estimate)	Ross (1998)		**Average Chinook Reach Survival 0.884**		**Average Steelhead Reach Survival 0.952**	**0.068**
Four Snake River Projects	Bjornn et al. (1992)	0.870		0.813		-0.057
Four Snake River Projects	Bjornn et al. (1994)	0.810		0.870		0.060
Four Snake River Projects	Bjornn et al. (1995)	0.861		0.813		-0.048
Four Snake River Projects Mean			**0.847**		**0.832**	**-0.015**
Estimate for Eight-Dam System (Snake R. Steelhead Total FCRPS Reach Estimate)	**Ross (1998)**		**Average Chinook Reach Survival 0.748**		**Average Steelhead Reach Survival 0.792**	**0.044**

are rare. In 1994, the only year for which kelt estimates at an FCRPS project have been published, 47 wild Snake River steelhead kelts passed downstream via the juvenile bypass system at Lower Granite Dam (Hurson et al. 1996). This corresponds to approximately 0.6% of the TAC (1997) estimates of the number of wild steelhead adults that passed Lower Granite Dam during either 1993 or 1994. It is possible that a higher proportion of spawners may have migrated downstream as kelts if they passed Lower Granite Dam through other routes (e.g., through turbines or spillway). The number of kelts that passed Lower Granite Dam through turbines in 1994 is unknown. Because of very limited spill, it is likely that few kelts passed via the spillway during 1994. The number of Snake River steelhead kelts passing other FCRPS dams is unknown, as are numbers of Upper Columbia River and Lower Columbia River steelhead passing FCRPS dams.

The mortality of kelts passing FCRPS projects has not been estimated. For those that pass through turbines, the mortality is likely to be at least as high as that estimated for upstream-migrating adults that fall back through turbines (see discussion above). It is unlikely that many kelts survive dam passage to spawn a second time.

Prior to construction of most lower Columbia River and lower Snake River dams, the proportion of repeat-spawning summer steelhead in the Snake and Columbia Rivers was less than five percent (3.4% [Long and Griffin 1937]; 1.6% [Whitt 1954]). Repeat-spawning in winter steelhead (e.g., some populations of the Lower Columbia River steelhead ESU) was apparently as high as 12% (Long and Griffin 1937). Recently, in the lower Columbia River, summer steelhead populations that do not pass through any dams (Kalama Rivers -- Lower Columbia River ESU) or that pass through only one dam (Klickitat River -- Middle Columbia River ESU) have approximately seven percent and three percent proportions of repeat spawners, respectively (Howell et al. 1985, cited in Busby et al. 1996). Lower Columbia River ESU winter steelhead that do not pass through any dams (Cowlitz and Kalama Rivers) have approximately four percent and eight percent repeat spawners, respectively (Howell et al. 1985, cited in Busby et al. 1996).

General - Timing and Applicability of Adult Chinook Measures for Adult Steelhead

In general, the proposed action provides comparable measures for protection of adult steelhead as those contained in the 1995 RPA for protection of adult chinook. Although steelhead are present in the Snake and lower Columbia Rivers during the winter, limited monitoring during this period suggests that movement stops when temperatures fall to 4 to 5° C (reviewed in Bjornn and Peery 1992). During winter maintenance periods, one adult fishway remains operational at all times at federal projects with two fish ladders. At Lower Granite and Little Goose Dams, which have only one adult fishway, ladders are inoperable for only short periods during winter maintenance.

VI.A.3. Combination of Water Regulation, Impoundment, and Barriers to Migration With Respect to Biological Requirements Within the Action Area

VI.A.3.a. Combined Effects of Water Regulation, Impoundment, and Barriers to Migration With Respect to Biological Requirements Within the Action Area

The effects previously described in Sections VI.A.1 and VI.A.2 describe the impact of the proposed actions on action-area biological requirements. Additional impacts resulting from the combined effects of water regulation, impoundment, and barriers to migration are not apparent.

VI.A.3.b. Reduction of Adverse Combined Effects of Water Regulation, Impoundment, and Barriers to Migration Through Proposed Measures

VI.A.3.b.1) Reduction of Adverse Combined Effects of Water Regulation, Impoundment, and Barriers to Migration Through Transportation of Juveniles

Most studies indicate that transported juvenile steelhead return at a higher rate than inriver control fish similarly collected and marked, but allowed to continue their migration inriver under the current hydroelectric system configuration (reviewed in Appendix B). However, there is continuing controversy regarding the application of these results to mitigation measures affecting inriver fish runs, which are not collected and handled in the same manner as the experimental controls. Additionally, concerns regarding the lack of information on population-specific effects of transportation, relative to inriver migration under current conditions, prompted the Independent Scientific Advisory Board (ISAB 1998) to recommend a "spread-the-risk" policy in 1998, in which the majority of migrants of any salmon or steelhead stock would not be transported.

Interim Action in the 1995 RPA The 1995 RPA Measure 3 required transportation around reservoirs and dams of most chinook and sockeye salmon, to avoid mortality associated with impoundment and dam passage. The Technical Management Team (TMT) was given flexibility to reduce the percentage of juveniles transported from a given project under some circumstances (e.g., by spilling at collector projects at flow levels below triggers [1995 RPA Measure 2] or by returning collected fish to the river [1995 RPA Measure 3]). The 1995 RPA Measure 3 concluded that, for McNary Dam, "there is sufficient uncertainty regarding benefits of transported yearling salmon to warrant suspending transport from that site during the spring." The 1995 RPA Measure 9 specified that barge exits should be enlarged to facilitate passage of transported juveniles from barges and 1995 RPA Measure 25 specified that new barges should be constructed to reduce holding time of juveniles prior to barging. IT 8 required a study of short-haul barging operations.

Supplemental Proposed Action As described in Section III, the proposed action includes various measures to adopt the ISAB's (1998) recommendation to "spread-the-risk" among transportation and inriver migration for listed stocks and to reduce the proportion of fish transported by truck.

Transportation from Snake River projects would be as described in the 1995 RPA, with the exception of modifications to 1995 RPA Measures 2 and 3. The Lower Granite spill trigger would change from 100 kcfs (as described in 1995 RPA Measure 2) to 85 kcfs, as originally proposed by NMFS in Appendix B. Rationale for this change is described in that appendix and in Section III. The effect of this change on transportation is a reduction in the proportion of fish approaching Lower Granite Dam that will be transported from that project in years in which the seasonal spring average flow is between 85 and 99 kcfs. Another change is to transport all juveniles collected at each Snake River collector project. The 1995 RPA Measure 3 previously gave the TMT flexibility to "recommend that fish be returned to the river to migrate under other circumstances if credible evidence is presented that inriver migration will be beneficial." The 1995 RPA Measure 3 would also be modified to allow an experiment involving transportation from McNary Dam in 1999 or possibly future years. The immediate purpose of the experiment would be to evaluate the apparent high mortality of transported yearling chinook salmon from this project as determined from PIT-tag detections, with the intention of identifying means by which the problem can be corrected. The ultimate purpose of the experiment will be to allow future transportation of Upper Columbia River steelhead from McNary Dam in order to spread the risk between transportation and inriver migration for this ESU. Additional details are included in Section III and Appendix B.

<u>Long-Term Action in the 1995 RPA</u> Some of the elements described in the interim action also continue as long-term actions (e.g., construction of new barges). Additionally, maximum transportation is considered one of the two major pathways for system operation following 1999. Model analyses in the 1995 FCRPS biological opinion indicated that under assumptions of a weak flow:survival relationship and high post-Bonneville survival of transported fish, survival and recovery of listed Snake River chinook stocks is possible by maximizing transportation. Several of the elements associated with long-term bypass improvements (VI.A.2.b.2), including development of surface bypass/collectors to improve collection of fish for transportation at some projects and improve inriver survival of uncollected fish at others, also support the long-term transportation option.

VI.A.3.b.2) Reduction of Adverse Combined Effects of Water Regulation, Impoundment, and Barriers to Migration Through Natural River Drawdown

Breaching dams and lowering reservoirs to natural (pre-impoundment) river levels have the potential to reduce adverse effects at the specific projects that are breached. Some level of mortality, above pre-impoundment natural mortality, may still be associated with natural river drawdowns because some period of time may be required for sediment to be flushed, natural channel conditions to stabilize, and predator populations to adjust to new habitat conditions. There may also be additional adverse effects associated with removing collector projects, since juveniles previously placed on barges would now have to migrate through four lower river dams and reservoirs that are currently avoided by transported fish.

Long-Term Action in the 1995 RPA The 1995 RPA Measure 10 requires that the Corps complete necessary feasibility, design and engineering work to allow drawdown of Snake River reservoirs to begin by 2000. Modeling analyses described in the 1995 FCRPS biological opinion concluded that under assumptions of a strong flow:survival relationship and poor survival of transported fish below Bonneville Dam, drawdown of four Snake River reservoirs was necessary to ensure survival and recovery of listed Snake River salmon.

Supplemental Proposed Action As described in Section III, the proposed action includes a feasibility study to determine long-term configuration of the lower Columbia River reach. This feasibility study will include consideration of John Day and McNary drawdown, full-flow bypass at some projects, as well as other measures already anticipated in the 1995 RPA.

VI.A.3.c. Relative Combined Effects of Water Regulation, Impoundment, and Barriers to Migration and Measures to Reduce Associated Mortality, on Listed Steelhead and Snake River Salmon

VI.A.3.c.1) Juveniles

VI.A.3.c.1)a) Juvenile Snake River Steelhead

In-River Survival Under Interim Operations Recent PIT-tag studies of the survival through various reaches (combinations of dams and reservoirs) of the Snake River are included in Table VI-7. Estimates of survival through the Lower Granite Reservoir to Lower Monumental Dam reach suggest that wild Snake River spring/summer chinook salmon survive at slightly higher rates (approximately 1.2% to 3.2% higher survival per project) than wild Snake River steelhead (Smith et al. 1998 and Schiewe 1997b; Table VI-7). Results of studies involving hatchery fish or mixed hatchery and wild fish through river reaches, which in some instances include estimates of survival to McNary Dam, are variable, with Snake River steelhead surviving at higher rates than Snake River spring/summer chinook in some cases and at lower rates in others.

Estimates of wild Snake River steelhead and chinook survival through projects below Lower Monumental Dam under recent conditions are not currently available. Ideally, passage-simulation models, such as those considered in the 1995 FCRPS Biological Opinion and in the PATH process, with alternative functional relationships suggested by the results of the Snake River survival study that are applied to lower river projects, could be used to estimate expected survival past all FCRPS projects under the proposed action. As pointed out in the 1995 FCRPS biological opinion, the two primary alternative passage simulation models in the region predicted strikingly dissimilar survival of Snake River spring/summer chinook salmon and Snake River fall chinook salmon under the 1995 RPA, and this discrepancy is still unresolved for Snake River spring/summer chinook salmon survival estimates (Marmorek and Peters 1998 - Draft Report). It is likely that the two models would also produce dissimilar results for steelhead. The NMFS has previously considered it important to obtain results from both models when analyzing the

Table VI-7. Seasonal average estimates of survival of yearling chinook and steelhead released in the Snake River, ascertained from PIT-tagging 1994-1996. A "project" refers to a dam + reservoir combination and a "reach" refers to river segment composed of one or more projects. Estimates in normal typeface are those reported in cited research. **Bold estimates are calculated in this table as: Mean Per-Project Survival = (Reach Survival)$^{-(\text{Number of Projects})}$; Approximate Eight-Project Survival = (Mean Per-Project Survival)^{8}.**

Study	Reach	Number of Projects	Steelhead Reach Survival (and **Mean Per-Project Survival**)	**Approximate Eight-Project Steelhead Survival**	Yearling Chinook Reach Survival (and **Mean Per-Project Survival**)	**Approximate Eight-Project Yearling Chinook Survival**	**Difference in Per-Project (and Eight-Project) Survival [SH - CH]**
1994 Primary Release Groups Weighted Means (Smith et al. 1998, Tables E1 and E2)	Silcott Island (LGR Reservoir) - Lower Monumental Dam	3	0.590 **(0.838)** (Hatchery) [4/23-5/16]	**0.243** (H)	0.645 **(0.864)** (Hatchery) [4/16-5/11]	**0.311** (H)	**-0.026 (-0.068)** (H)
1994 Snake Trap Releases Weighted Means (Smith et al. 1998, Table E8)	Snake Trap (Above LGR Reservoir) - Lower Monumental Dam	3	0.351 **(0.705)** (Hatchery) [4/13-7/8] 0.515 **(0.802)** (Wild) [4/13-7/5]	**0.061** (H) **0.171** (W)	0.571 **(0.823)** (Hatchery) [4/13-7/6] 0.580 **(0.834)** (Wild) [4/13-7/6]	**0.210** (H) **0.234** (W)	**-0.118 (-0.149)** (H) **-0.032 (-0.063)** (W)
1995 Primary Release Groups Weighted Means (Smith et al. 1998, Tables E1 and E2)	Port of Wilma (LGR Reservoir) - Lower Monumental Dam	3	0.788 **(0.924)** (Hatchery) [4/22-5/12]	**0.531** (H)	0.779 **(0.920)** (Hatchery) [4/9-5/5]	**0.513** (H)	**0.004 (0.018)** (H)
1995 Snake Trap Releases Weighted Means (Smith et al. 1998, Table E9)	Snake Trap (Above LGR Reservoir) - Lower Monumental Dam	3	0.752 **(0.909)** (Hatchery) [3/31-5/31] 0.790 **(0.924)** (Wild) [3/31-5/31]	**0.466** (H) **0.531** (W)	0.729 **(0.900)** (Hatchery) [3/31-5/31] 0.844 **(0.945)** (Wild) [3/31-5/31]	**0.430** (H) **0.636** (W)	**0.009 (0.036)** (H) **-0.021 (-0.105)** (W)

Study	Reach	Number of Projects	Steelhead Reach Survival (and **Mean Per-Project Survival**)	**Approximate Eight-Project Steelhead Survival**	Yearling Chinook Reach Survival (and **Mean Per-Project Survival)**	**Approximate Eight-Project Yearling Chinook Survival**	**Difference in Per-Project (and Eight-Project) Survival [SH - CH]**
1995 Weekly Transport + Other Release Groups Unweighted Means (S. Smith, pers. comm. 1998)	Lower Granite Dam - McNary Dam	4.5	0.592 **(0.890)** (Mixed) [4/9-5/27]	**0.394** (M)	0.624 **(0.901)** (Mixed) [4/4-6/12]	**0.434** (M)	**-0.011 (-0.040)** (M)
1996 Weekly Transport + Other Release Groups Unweighted Means (S. Smith, pers. comm. 1998)	Lower Granite Dam - McNary Dam	4.5	0.615 **(0.899)** (Mixed) [4/11-5/29]	**0.427** (M)	0.587 **(0.888)** (Mixed) [4/16-5/27]	**0.387** (M)	**0.011 (0.040)** (M)
1996 Snake Trap Releases Weighted Means (Smith et al. 1998, Table 24)	Snake Trap (Above LGR Reservoir) - Lower Monumental Dam	3	0.954 **(0.984)** (Hatchery) [4/15-5/15] 0.951 **(0.983)** (Wild) [4/15-5/15]	**0.879** (H) **0.872** (W)	0.703 **(0.889)** (Hatchery) [4/8-5/15] 0.963 **(0.988)** (Wild) [4/5-5/15]	**0.390** (H) **0.908** (W)	**0.095 (0.489)** (H) **-0.012 (-0.036)** (W)
1997 Preliminary Information (Schiewe 1997b)	Lower Granite Dam - McNary Dam	4.5	0.640 **(0.906)** (Hatchery)	**0.454** (H)	0.672 **(0.915)** (Mixed)	**0.491** (M)	**-0.009 (0.037)** (M)

effects of proposed actions in biological opinions. Results from one of the passage simulation models (CRiSP) were submitted to NMFS along with comments on the draft Supplemental Biological Opinion (Anderson 1998). The second passage simulation model (FLUSH) currently is not configured to generate steelhead survival estimates, so it is not possible to compare estimates generated by the two models. The CRiSP model results that were received provided selected steelhead survival estimates, but provided no corresponding spring/summer chinook survival estimates for comparison. Because results from both passage models were not available for this biological opinion and because the results obtained from one model were not reviewed by the full PATH group do not include a comparison between steelhead and spring/summer chinook salmon survival, the information provided by Anderson (1998) was not relied upon in reaching conclusions of this opinion, but is discussed anecdotally where appropriate.

The reach survival estimates for wild smolts to Lower Monumental Dam in Table VI-7 indicate that the per-project survival difference between Snake River steelhead and Snake River spring/summer chinook salmon is very small, as described above. However, the difference may be more significant if passage through all eight dams is considered. Additionally, the routing through dams of PIT-tagged fish in the passage survival studies differs from the passage routing of the majority of migrants, which were not PIT-tagged. This is because, during 1994 through 1996, all PIT-tagged fish that went into bypasses at Snake River collector projects were routed back to the river, but all unPIT-tagged fish were collected for transportation. Therefore, inriver migrants that were not included in the survival studies passed Snake River collector projects only via the turbines or spillways and likely suffered higher mortality than did PIT-tagged experimental fish, which also could pass those projects via bypasses.

In the absence of inriver survival estimates from either passage model (Anderson 1998 estimated survival of combined inriver and transported fish, as discussed below), a very simple approach was used to estimate the relative survival of the two species through all eight dams. The resulting estimates should not be interpreted as NMFS' expectation of the future survival of inriver migrating fish under the proposed action. Rather, these estimates represent approximate survival of the two species through eight projects, estimated in an identical manner for each species, based on conditions experienced in 1994 through 1996. The primary assumptions for this simple approach are: (1) the survival of wild Snake River steelhead and Snake River spring/summer chinook through each project below Lower Monumental Dam are equal to the mean per-project survival through Lower Monumental Dam, as described in Table VI-7; and (2) survival of inriver migrants under the interim operation (which transports all fish bypassed at three Snake River collector projects, leaving inriver fish to pass only through turbines or spill at those projects) are approximately 80% of the survival of fish passing inriver (pers. comm., P. Wilson, CBFWA [FLUSH model], and J. Hayes, Univ. of Washington [CRiSP model], 1998). The first assumption appears reasonable given estimates of survival for hatchery and mixed smolts through McNary Dam in Table VI-7 and given one estimate of mixed hatchery and wild spring/summer chinook survival through John Day Reservoir in 1996, which was similar to mean survival through Snake River projects (Smith et al. 1998). The second assumption is based on detailed routing estimates of spring/summer chinook in passage simulation model analyses included in Marmorek and Peters

(1998 - Draft Report). Its application to steelhead is, at this point, speculative. Using this approach, the range of inriver survival differences between Snake River steelhead and Snake River spring/summer chinook through eight projects is approximately 3.6% to 10.5% (Table VI-7).

Direct Transportation Survival PATH has estimated that direct survival of yearling chinook salmon during transportation is high, and an estimate of 98% has been used in modeling (Marmorek and Peters 1998 - Draft Report). There are no studies in which direct transportation survival of steelhead has been empirically estimated, but it is likely that 98% is also a reasonable estimate for steelhead direct transport survival.

Combined Transport and In-River Direct Survival Under Interim Operations Comparative passage model estimates of combined transported and inriver migrant Snake River steelhead and chinook survival to below Bonneville Dam were not conducted for this biological opinion, but are expected to be available within the next one to two years from PATH. A CRiSP-model estimate of a “spread the risk” action, presumably comparable to the proposed action, given the 1998 predicted flows, indicated 71% survival of Snake River steelhead to the Bonneville tailrace (Anderson 1998). The exact assumptions used to generate this estimate have not been reviewed by PATH or NMFS at this point and no comparable spring/summer chinook survival estimates were presented.

In the absence of passage simulation modeling that would allow comparison of steelhead and spring/summer chinook survival, a very simple analysis to compare each species’ survival under recent conditions indicates that direct survival to below Bonneville Dam is at least as high for juvenile steelhead as it is for juvenile spring/summer chinook salmon under the interim operation. The elements of this analysis are: (1) the range of inriver survivals estimated in Table VI-7; (2) the direct transport survival rate estimated above (98% for each species); and (3) the relative proportion of fish entering Lower Granite pool that are then transported.

Graves and Ross (1998) estimate that under recent interim operations a larger proportion of wild Snake River steelhead than wild Snake River spring/summer chinook salmon have been transported from the Snake River (Table VI-8). Estimates range from 3 to 23% more steelhead transported than chinook in recent years, depending upon fish guidance assumptions and annual operations. These estimates are based on the proportion of juveniles arriving at Lower Granite Dam and therefore over-estimate the proportion of Lower Granite Reservoir arrivals that are transported. Iwamoto et al. (1994) and Muir et al. (1995) suggest that most of the Lower Granite combined reservoir and dam reach mortality during the spring occurs at the dam, with little occurring in the reservoir. Some previous PATH analyses have considered 95% to be a conservative approximation of spring/summer chinook survival through Lower Granite Reservoir (Chapter 6 in Marmorek et al. 1996).

Table VI-8. Estimates of percentage of smolt arriving at Lower Granite Dam that have been transported from Snake River collector projects during the last three years of interim operations (Graves and Ross 1998). Results for two assumptions regarding fish guidance efficiency (FGE) are presented. In one, extended-length bar screens are assumed to have the same FGE as standard traveling screens (ESBS = STS). In the second, the FGE of extended-length screens is assumed to be higher (STS < ESBS). [H = hatchery, W = wild]

Year	Snake River Steelhead		Snake River Yearling Chinook		Difference (SH-CH)	
	STS = ESBS	STS < ESBS	STS = ESBS	STS < ESBS	STS = ESBS	STS < ESBS
1995	0.800 (H) 0.919 (W)	N/A	0.583 (H) 0.674 (W)	N/A	0.22H 0.23W	N/A
1996	0.550 (H) 0.641 (W)	0.550 (H) 0.641 (W)	0.341 (H) 0.422 (W)	0.460 (H) 0.597 (W)	0.21H 0.22W	0.09H 0.06W
1997	0.498 (H) 0.579 (W)	0.498 (H) 0.579 (W)	0.318 (H) 0.389 (W)	0.426 (H) 0.552 (W)	0.18H 0.19W	0.07H 0.03W

The above information can be combined as follows:

(1)
$$S_{DIRECT} = [T \times S_{LGR} \times S_{TRAN}] + [(1-(T \times S_{LGR})) \times S_{INRIVER}]$$

where S_{DIRECT} is direct survival to below Bonneville Dam; T is the proportion of fish arriving at Lower Granite Dam that are subsequently collected for transportation from all collector projects (Table VI-8); S_{LGR} is the survival from the head of Lower Granite Reservoir to Lower Granite Dam (assumed to be 0.95 for this analysis -- see above); S_{TRAN} is direct survival of transported fish from collection until release (assumed to be 0.98 in this analysis - see above); and $S_{IN\text{-}RIVER}$ is direct survival of uncollected fish that migrate inriver (0.8 times estimates in Table VI-7 - see above). Combining the ranges of estimates for wild steelhead and spring/summer chinook in Tables 7 and 8 allows estimates of direct survival in 1995 and 1996 for wild smolts of each species, using comparable methods. Table VI-9 indicates that, under the interim action, direct survival to below Bonneville Dam during those years was at least as high, and possibly somewhat higher, for juvenile steelhead as it was for juvenile spring/summer chinook salmon.

Combined Transport and In-River Direct+Indirect Survival Under Interim Operations Analyses to this point assume that effects of the FCRPS end when smolts pass, or are released from transport, immediately below Bonneville Dam. Various indirect effects of the FCRPS have been proposed beyond this point, and several hypotheses are being articulated and evaluated by the PATH analytical group (Marmorek and Peters 1998 - Draft Report). Results are expected to be available within the next one to two years.

Table VI-9. Estimates of direct survival to below Bonneville Dam of transported and untransported wild Snake River steelhead and wild Snake River spring/summer chinook salmon. **The purpose of this table is to compare relative survival of the two species in recent years, using similar techniques - it is not to make predictions regarding future survival.** In-river survival of wild fish is from **Table VI-7**; transport proportions are from **Table VI-8**; and direct survival estimates are from Equation 1, with constants defined as in text. Complete information for wild fish in 1994 and 1997 is not available at this time.

Year	Steelhead			Spring/Summer Chinook			Difference in Direct Survival (SH-CH)
	In-River Survival	Transport Proportion	Direct Survival	In-River Survival	Transport Proportion	Direct Survival	
1994	0.8*0.171			0.8*0.234			N/A
1995	0.8*0.531	0.919	0.910	0.8*0.636	0.674	0.811	0.099
1996	0.8*0.872	0.641	0.870	0.8*0.908	0.422 to 0.597	0.828 to 0.870	-0.001 to +0.041
1997		0.579			0.389 to 0.552		N/A

Table VI-10. Summary of recent studies comparing survival of transported vs inriver migrants for Snake River steelhead and Snake River spring/summer chinook salmon. All transported fish were barged, rather than trucked. 95 % Confidence Intervals in parentheses.

Study	Steelhead Transport:In-River Return Rate	Yearling Chinook Transport:In-River Return Rate	Difference (SH-CH)
Matthews et al. (1992) Mixed Hatchery/Wild	2.0 (1.4-2.7)	1.6 (1.01-2.47)	0.4
Harmon et al. (1995) Mixed Hatchery/Wild	2.1 (1.3-3.5)	2.4 (1.4-4.3)	-0.3

Transport studies that include information on survival through the estuarine and ocean environments provide one type of information that is useful in evaluating the indirect effects of transportation. Recent studies (i.e., since 1986) comparing transported and inriver migrating Snake River steelhead and Snake River spring/summer chinook survival indicate higher returns of transported than untransported juveniles for both species (summarized in Table VI-10). The transport:inriver return rate (T/I return rate) for Snake River steelhead and Snake River spring/summer chinook salmon in these studies varies slightly, but is generally similar for both species. Results of more recent transport studies, conducted in 1995 and 1996, will become available as adults return during the next three years.

In-River Survival Under Long-Term Actions

Drawdown Long-Term Action. Estimates of the inriver survival of Snake River steelhead through the FCRPS that may occur as a result of drawdowns or future project passage improvements are not presently available. Such estimates are expected within the next one to two years from the PATH analytical group. However, it is likely that drawdowns will affect juvenile steelhead in a similar manner to Snake River spring/summer chinook salmon. For example, Table VI-11 indicates that survival of both yearling chinook and steelhead through free-flowing reaches of the Snake River above Lower Granite Dam are variable, with steelhead survival higher in three of the available years and yearling chinook survival higher in one year. Under the assumption that survival in a future drawn-down section of the Snake River will (after some equilibration period) be similar to survival in upstream free-flowing reaches, Table VI-11 suggests that steelhead direct survival through that reach may be between 7.5% lower to 12.5% higher than chinook survival, and will average approximately two percent higher. Effects of drawdowns on the indirect survival (i.e., below Bonneville Dam) of steelhead versus chinook cannot be described at this time.

Transport Long-Term Action. Estimates of the inriver survival of Snake River steelhead through the FCRPS that may occur as a result of maximizing transportation and implementing future project passage improvements are not presently available and are also expected within one to two years from the PATH analytical group. However, it is likely that these measures will affect juvenile steelhead in a similar manner to Snake River spring/summer chinook salmon. A higher percentage of juveniles will be transported under this option, leaving fewer to migrate in the river. Because spill may be curtailed at collector projects, it is likely that survival of untransported fish remaining to migrate inriver will be reduced unless passage improvements at non-collector projects can offset this effect. Because, as described above, steelhead and chinook appear to be affected similarly by spill and turbine passage, and because steelhead appear to have slightly higher survival than chinook through bypasses, the relative impact of the long-term transportation action on inriver survival should be similar for each species. If guidance remains higher for steelhead than for yearling chinook with future collection facilities, more steelhead

Table VI-11. Estimates of wild juvenile steelhead and wild yearling chinook survival in free-flowing river sections above Lower Granite Dam. Estimates of survival from Whitebird (Salmon Trap) to Lower Granite (LGR) tailrace and from the head of LGR Reservoir (Snake Trap) to LGR dam from Table 24 and Appendix Tables E7-E9 of Smith et al. (1998). These estimates do not necessarily reflect survival of the same population of fish through the two reaches, so the method of removing effects of LGR Reservoir and dam passage in Column (3) is imperfect. **Bold estimates** are those which appear to be extremely high, possibly due to the methodology used in this table and, in the case of the 1996 estimate, due to high standard error associated with the original reach survival estimate.

	(1) Whitebird (Salmon River) to LGR Tailrace (233 km)		**(2) Head of LGR Reservoir to LGR Tailrace (52 km)**		**(3) = (1)/(2) Estimated Survival Whitebird to Head of LGR Reservoir (181 km)**		**(4) = Mean per-km survival from (3) raised to 210th power Estimated Survival Through Snake Drawdown Section (210 km)**		**Difference (SH - CH)**
Year	**Steelhead**	**Chinook**	**Steelhead**	**Chinook**	**Steelhead**	**Chinook**	**Steelhead**	**Chinook**	
1993	0.832	0.832	0.898	0.839	0.927	**0.992**	0.915	**0.990**	**-0.075**
1994	0.75	0.788	0.836	0.894	0.897	0.881	0.882	0.864	0.018
1995	0.892	0.863	0.955	0.944	0.934	0.914	0.924	0.901	0.023
1996	**0.967**	0.882	0.945	0.964	**1.023**	0.915	**1.027**	0.902	**0.125**

than chinook smolts will be transported and therefore direct survival of steelhead will be as high or higher than that of chinook, as described above. Effects of maximum transportation on steelhead versus chinook indirect (below Bonneville) survival cannot be described at this time.

VI.A.3.c.1)b) Juvenile Upper Columbia River Steelhead

Reach survival study estimates for juvenile Upper Columbia River steelhead are currently unavailable. Between 1985 through 1987 the Fish Passage Center estimated survival through the mid-Columbia River above McNary Dam, but the reach did not include passage through federal projects and the authors believed that the estimates were biased due to differential smoltification of steelhead in the upriver and downriver paired releases (FPC 1988). The best available information for survival of juvenile Upper Columbia River steelhead through federal projects in the lower Columbia River is extrapolation of survival estimates from Snake River steelhead. As described above, it appears that inriver survival of juvenile wild steelhead is slightly lower than that of juvenile wild spring/summer chinook salmon passing through the same reach. Because there will be no transportation of Upper Columbia steelhead until an apparent problem at McNary Dam has been either corrected or shown to be insubstantial, direct survival estimates for Upper Columbia steelhead through the FCRPS projects to below Bonneville Dam are identical to inriver survival estimates. The CRiSP passage model estimates provided by Anderson (1998) suggest that Upper Columbia River steelhead survival through the lower Columbia River FCRPS projects, without transportation at McNary Dam, is approximately 29% to 30%, but the assumptions and methods used to generate these estimates have not been reviewed by PATH or NMFS at this point. As with Snake River steelhead, indirect survival below Bonneville Dam is unknown at present.

It is likely that juvenile Upper Columbia River steelhead will be affected by long-term actions in a manner similar to both Snake River steelhead and Snake River spring/summer chinook salmon. Estimates of steelhead and yearling chinook survival through free-flowing sections of the lower Columbia River are not available. However, because differences in survival between steelhead and chinook were not apparent in free-flowing sections of the Snake River, it is likely that the difference in survival between the two species through drawn down sections of the lower Columbia River also would be insubstantial. Similarly, it is likely that once experiments have determined the nature of apparent collection and transportation problems at McNary Dam and either corrected them or shown them to be insubstantial, maximum transportation at McNary would provide survival through the lower Columbia River for steelhead, similar to that experienced by chinook. Steelhead transportation studies have not been conducted from McNary Dam under recent conditions, but earlier studies of transport from McNary showed that steelhead T:I ratios of 1.3 to 3.0 in 1978 through 1980 encompassed the range of yearling chinook T:I ratios from that project (means of 1.6 in 1987 through 1988, 95% CI 1.0 to 2.25) (Appendix B).

VI.A.3.c.1)c) Juvenile Lower Columbia River Steelhead

Reach survival estimates for juvenile Lower Columbia River steelhead are currently unavailable. Based on studies of Snake River steelhead, it is likely that survival of wild Lower Columbia River steelhead through Bonneville Dam and reservoir is slightly lower than that of wild yearling chinook salmon. Because Lower Columbia River steelhead pass, at most, one FCRPS project, neither transportation or future drawdowns are necessary to ensure that their survival through the FCRPS is higher than that of other stocks, which must pass through four to eight federal projects.

VI.A.3.c.2) Adults of All Species

Estimates of upriver survival under interim operations are presented for each species in Section VI.A.2.c.2) for each steelhead ESU. Under a long-term drawdown scenario, survival of Snake River steelhead should increase substantially, depending upon the number of projects that are breached. If four Snake River projects are drawn down, adult mortality of Snake River steelhead above McNary Dam would be reduced from approximately 17% currently to a very low level - possibly near zero. This reduction would be nearly identical to that experienced by adult chinook salmon (Table VI-6). A drawdown of John Day or McNary would increase survival of this ESU additionally, as it would for the Upper Columbia steelhead ESU. The Lower Columbia River steelhead ESU would not be affected by changes in adult survival resulting from drawdowns. It is unlikely that there would be any change in adult survival for any of the steelhead ESUs as a result of the maximum transportation long-term option.

VI.A.4. Species-Level Effects of the Proposed Action

VI.A.4.a. Snake River Steelhead

Using the interim analytical method described in Section V, the preliminary estimate of the necessary historical upper dam smolt-to-adult return rate (Escapement SAR [defined in Section V.A.2.a]) range for Snake River spring/summer chinook is 2.3% to 4.5% (geometric mean 2.9%). Escapement SARs for the three most recent years, estimated by similar methods, range from 0.2% to 1.0% (geometric mean 0.4%), and the mean incremental change in survival required to meet historical Escapement SARs is a factor of 6.9 times the recent survival rates (Petrosky and Schaller 1998 - Draft Report; Table VI-12). Using the harvest-adjusted SAR definition (Escapement + Harvest SAR [defined in Section V.A.2.a]), corresponding estimates are a historical mean of 4.9%, a recent mean of 0.4%, and a necessary 11.2-fold increase in survival over recent rates (Petrosky and Schaller 1998 - Draft Report; Table VI-13). The sensitivity of these estimates to alternative assumptions is currently being reviewed by a PATH subcommittee and estimates are subject to change prior to completion of the final PATH report. Of particular concern are changes in the field sampling and analytical methods between historical and recent periods (Paulsen and Giorgi 1998), the significance of which are poorly understood at present.

The preliminary estimate of the necessary historical Escapement SAR range for Snake River steelhead is 3.4% to 4.2% (geometric mean 3.8%). Escapement SARs for the five most recent years, estimated by similar methods, range from 0.5% to 1.5% (geometric mean 0.8%), and the mean incremental survival change required to meet historical SARs is a factor of 4.6 times the recent survival rates (Table 9 in Petrosky and Schaller 1998 - Draft Report - based on data in Petrosky 1998b - Draft Report; Table VI-12). Using the Escapement + Harvest SAR definition, corresponding estimates are a historical mean of 5.6%, a recent mean of 1.5%, and a necessary 3.8-fold increase in survival over recent rates (Table 9 in Petrosky and Schaller 1998 - Draft Report - based on data in Petrosky 1998b - Draft Report; Table VI-13). The sensitivity of these estimates to alternative assumptions is currently being reviewed by a PATH subcommittee and estimates are subject to change prior to completion of the final PATH report.

This preliminary analysis suggests that, given the assumptions of the interim method described in Section V, the incremental change in survival required for Snake River steelhead to achieve an acceptable probability of survival and recovery is no greater than that required for Snake River spring/summer chinook salmon, and possibly less. Because the proposed action has already been determined not to jeopardize listed Snake River spring/summer chinook salmon, this conclusion implies that, if the proposed action affects Snake River steelhead survival in the action area in the same manner as it affects Snake River spring/summer chinook survival, the proposed action also will not jeopardize Snake River steelhead. This same conclusion regarding the relative incremental survival changes needed for Snake River steelhead versus spring/summer chinook is reached using either of the alternative SAR definitions.

Table VI-12. Smolt-to-adult return rate (SAR) estimates to upper dam (Escapement SAR [defined in Section V.A.2.a]) during historical and recent periods for Snake River spring/summer chinook salmon, Snake River steelhead, and Upper Columbia River steelhead (Petrosky 1998b - Draft Report; Petrosky and Schaller 1998 - Draft Report; Cooney 1998 - Draft Memorandum).

	Snake River Spring/Summer Chinook	**Snake River Steelhead**	**Upper Columbia River Steelhead**
Historical SAR Range (Geometric Mean)	0.023 - 0.045 (0.029)	0.034 - 0.042 (0.038)	0.017 - 0.029 (0.022)
Recent SAR Range (Geometric Mean)	0.002 - 0.010 (0.004)	0.005 - 0.015 (0.008)	0.003 - 0.011 (0.006)
Necessary Incremental Change (Historical Mean ÷ Recent Mean)	6.9x	4.6x	3.7x

Table VI-13. Smolt-to-adult return rate (SAR) estimates to upper dam, adjusted for harvest (Escapement + Harvest SAR [defined in Section V.A.2.a]) during historical and recent periods for Snake River spring/summer chinook salmon, Snake River steelhead, and Upper Columbia River steelhead (Petrosky 1998b - Draft Report; Petrosky and Schaller 1998 - Draft Report; Cooney 1998 - Draft Memorandum).

	Snake River Spring/Summer Chinook	**Snake River Steelhead**	**Upper Columbia River Steelhead**
Historical SAR Range (Geometric Mean)	0.037- 0.073 (0.049)	0.045 - 0.064 (0.056)	0.025- 0.044 (0.034)
Recent SAR Range (Geometric Mean)	0.002 - 0.011 (0.004)	0.011 - 0.028 (0.015)	0.003 - 0.012 (0.007)
Necessary Incremental Change (Historical Mean ÷ Recent Mean)	11.2x	3.8x	4.9x

VI.A.4.b. Upper Columbia River Steelhead

Using the interim analytical method described in Section V, the preliminary estimate of the necessary historical upper dam smolt-to-adult return rate (Escapement SAR) range for Upper Columbia River steelhead is 1.7% to 2.9% (geometric mean 2.2%), the four most recent years' SARs, estimated by similar methods, range from 0.3% to 1.1% (geometric mean 0.6%), and the mean incremental survival change required to meet historical SARs is a factor of 3.7 times the recent survival rates (Cooney 1998 - Draft Memorandum; Table VI-12). These incremental changes can be compared with the 6.9-fold increase in Escapement SAR required for Snake River spring/summer chinook salmon (Table VI-12). Using the harvest-adjusted definition (Harvest + Escapement SAR), corresponding estimates are: a historical mean of 3.4%, a recent mean of 0.7%, and a necessary 4.9-fold increase in survival over recent rates (Cooney 1998 - Draft Memorandum; Table VI-13). This incremental change can be compared with the 11.2-fold increase in Escapement + Harvest SAR required for Snake River spring/summer chinook salmon (Table VI-13). Sensitivity of these estimates to alternative assumptions is currently being reviewed by a PATH subcommittee and estimates are subject to change prior to completion of the final PATH report.

This preliminary analysis suggests that, given the assumptions of the interim method described in Section V, the incremental change in survival required for Upper Columbia River steelhead to achieve an acceptable probability of survival and recovery is no greater than that required for Snake River spring/summer chinook salmon, and possibly less. Because the proposed action has already been determined not to jeopardize listed Snake River spring/summer chinook salmon, this conclusion implies that, if the proposed action affects Upper Columbia River steelhead survival in the action area in the same manner as it affects Snake River spring/summer chinook survival, the proposed action also will not jeopardize Upper Columbia River steelhead. This same conclusion regarding the relative incremental survival changes needed for Upper Columbia River steelhead vs. Snake River spring/summer chinook is reached using either of the alternative SAR definitions.

VI.A.4.c. Lower Columbia River Steelhead

It has not been possible to develop an interim analytical method to assess effects of the proposed action on species-level biological requirements of Lower Columbia River steelhead. However, qualitative considerations suggest that the proposed action is not likely to reduce the ability of this ESU to meet species-level biological requirements. Lower Columbia River steelhead pass, at most, one FCRPS project and therefore experience much less direct passage mortality than other listed ESUs considered in this biological opinion. While they experience effects of FCRPS water management downstream of Bonneville Dam (e.g., possible changes in timing of estuary arrival or in estuarine or Columbia River plume conditions), there is no reason to believe that those downstream effects are greater for this ESU than for other listed salmon and steelhead migrating through the lower Columbia River. Presumably, other sources of mortality play a greater role in determining whether this species will survive and recover than does operation of the FCRPS.

VI.A.5. Cumulative Effects

Cumulative Effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation." For the purposes of this analysis, the action area encompasses the Snake and Columbia Rivers, including areas outside the range of listed Snake River salmon that affect natural runoff of water into those areas that are within the listed species' range. Future federal actions, including the ongoing operation of hatcheries, fisheries, and land management activities are being or have been reviewed through separate Section 7 consultation processes. This includes consultation on the operation of five mid-Columbia River Public Utility District projects, for which a Section 7 consultation through the Federal Energy Regulatory Commission is underway. In addition, non-federal actions that require authorization under section 10 of the ESA will be evaluated under Section 7 consultations. Therefore, these actions are not considered cumulative to the proposed action.

VI.B. Effects of NMFS' Issuance of Section 10 Permits for Transportation and the Smolt Monitoring Program

VI.B.1. Effects of Modification of the Section 10 Permit for the Juvenile Transportation Program on All Species

The juvenile transportation program is an integral component of the proposed action during the interim period, as described in 1995 RPA Measure 4 and supplemental proposed actions in this biological opinion. Issuance of the Section 10 permit for the transportation program is necessary to implement the proposed action. Effects of bypass and collection of smolts on Snake River steelhead, Upper Columbia River steelhead, and Snake River spring/summer chinook survival are described in Section VI.A.2.c.1). Effects of adult fallback through bypass systems are assessed in Section VI.A.2.c.2). Effects of transportation, in terms of direct survival to below Bonneville Dam and in terms of relative survival to adults compared to inriver migrants, are compared in Section VI.A.3.c. Details regarding all aspects of the transportation program and its effect upon listed steelhead and salmon are included in Appendix B.

VI.B.2. Effects of Modification of the Section 10 Permit for the Smolt Monitoring Program on All Species

The smolt monitoring program is an integral component of the proposed action, as described in 1995 RPA Measure 13(a). Issuance of the Section 10 permit for the smolt monitoring program is necessary to implement the proposed action. Effects of bypass and collection of smolts on Snake River steelhead, Upper Columbia River steelhead, and Snake River spring/summer chinook survival are described in Section VI.A.2.c.1). Effects of adult fallback through bypasses is assessed in Section VI.A.2.c.2).

VII. FRAMEWORK COORDINATION

An April 24, 1996, letter from M. Fuhrman (Corps) to W. Stelle (NMFS) and a November 14, 1996, letter from W. Stelle (NMFS) to B. Bohn (Corps) outlined and implemented a "Framework" process for documenting the adaptive management process envisioned in the 1995 RPA Measure 26. Under the Framework process, NMFS reviews implementation of measures specified in the 1995 RPA measures, including schedule changes and other modifications resulting from new technical or economic considerations. In the November 14, 1996, letter, NMFS analyzed proposed schedule changes with respect to: (1) NMFS' ability to make decisions or implement long-term survival options according to the schedule called for in the 1995 FCRPS Biological Opinion and (2) the effects of each schedule change on the survival of listed Snake River salmon during the interim period. The NMFS concluded that several of the schedule changes considered in that letter would not reduce NMFS' ability to make long-term decisions and would have only minor effects on interim survival. Therefore, NMFS concluded that the schedule changes considered in November 1996 did not affect the conclusion in the 1995 FCRPS Biological Opinion that the 1995 RPA outlined in that document would not be likely to jeopardize listed Snake River salmon.

The Action Agencies' Biological Assessment reviews the current status of each of the 1995 RPA measures and notes that several elements of the schedule have been changed based on discussions in the System Configuration Team and Implementation Team. The NMFS has reviewed these changes and has documented these discussions in the Regional Forum. Additionally, the Action Agencies are considering several new supplemental measures that are expected to increase survival of listed Snake River salmon, including increased spill at several projects during the interim period. In net effect, adaptive management revisions made to date to the 1995 RPA will not reduce NMFS' ability to make long-term decisions and will have minor effects on the interim survival of listed Snake River salmon. Therefore, NMFS concludes that the continued implementation of the measures described in the 1995 RPA, together with the supplemental measures proposed in this Supplemental FCRPS Biological Opinion, is consistent with the expectations on which the 1995 FCRPS Biological Opinion was based. Further consultation on the effects of the FCRPS on the survival and recovery of Snake River spring/summer chinook salmon, Snake River fall chinook salmon, and Snake River sockeye salmon is not necessary at this time.

VIII. CONCLUSIONS

The method used for evaluating whether the proposed action would jeopardize listed species was described in Section V. Conclusions regarding the effect of the proposed action on each species are presented in this section within the context of step V.D: determine the likelihood that the species can be expected to survive, with an adequate potential for recovery, under the effects of the proposed or continuing action, the environmental baseline, and any cumulative effects, and considering measures for survival and recovery specific to other life stages. Specific decision elements necessary to reach a conclusion relative to step V.D are described for each species.

VIII.A. Snake River Steelhead

VIII.A.1. Determine Significance of the Aggregate Effect Upon the Particular Biological Requirements of the Listed Species in the Action Area (V.D.1)

As stated in Section V, the biological requirements of juvenile and adult Snake River steelhead and Snake River chinook species are the same within the action area. Thus, the action will not be likely to jeopardize Snake River steelhead if the change in survival associated with the action is the same or greater for steelhead, relative to chinook.

<u>Interim Actions to Reduce Mortality of Listed Fish and To Support the Long-Term Decision</u>

The reductions in mortality associated with the 1995 RPA and supplemental proposed action appear to be similar for the two species. This conclusion is based primarily upon the side-by-side analyses of the survival of Snake River steelhead and Snake River juvenile and adult chinook salmon through various project routes, transportation, and FCRPS reaches (Section VI), which indicate that, during the time period that the steelhead and chinook migrations overlap, the two species experience similar effects of the FCRPS.

Although the absolute juvenile survivals of the two species are not identical (e.g., reach survival of wild Snake River steelhead is somewhat lower than that of wild Snake River spring/summer chinook [Table VI-9] and direct survival to below Bonneville is higher for steelhead [Table VI-11]), the similarity of survival through various project routes suggests that juveniles of each species respond similarly to measures in the 1995 RPA and therefore experience similar incremental improvements in survival. This conclusion is inferred from empirical studies in which juvenile passage routing, travel time, or survival of both species was examined concurrently, as described in Section VI. Simulation modeling to specifically quantify and compare the incremental survival changes in each species was not available from PATH. When the PATH steelhead analysis is complete, this conclusion will have to be re-examined in light of the new information. One PATH participant submitted a summary of simulation modeling results that purported to demonstrate that certain elements of the supplemental proposed action had either negligible or detrimental effects on Snake River steelhead survival (Anderson 1998), but this analysis has not been reviewed by PATH or incorporated into a complete PATH analysis, it did not appear to analyze the full 1995 RPA plus supplemental proposed actions, and it did not contrast incremental changes for steelhead and chinook salmon.

Indirect mortality below Bonneville Dam resulting from passage through the FCRPS and estuarine and ocean mortality resulting from federal water management is undetermined for either species, but is the subject of ongoing analyses by the PATH analytical team (Marmorek et al. 1998 - Draft Report). Until these analysis are completed, NMFS assumes that changes in indirect passage mortality and downstream mortality related to federal water management, if any, are similar for the two species.

Adult passage mortality of both Snake River steelhead and Snake River chinook is very similar for the two species, as described in Section VI, so both species are likely to have similar changes in adult survival as a result of the proposed action.

The timing and geographical range of measures to reduce FCRPS mortality appear to be sufficient for similar protection of juvenile Snake River steelhead, compared to protection of juvenile Snake River spring/summer chinook salmon. For example, in response to the slightly earlier arrival timing of steelhead smolts at Lower Granite Dam, the Action Agencies have included a supplemental proposed action to move the initiation of the Lower Granite spring spill planning date from April 10 to April 3.

Supplemental measures to reduce hydrosystem mortality are being implemented under the proposed action, consistent with the intent of the interim measures called for in the 1995 RPA. In addition to implementing the 1995 RPA, the proposed action includes supplemental measures to increase spill at several projects, intended to increase the survival of untransported fish, and a measure to reduce the proportion of transported fish that are trucked.

Long-Term Major Structural Improvements to the FCRPS

Currently available information is not sufficient to conclude that the interim operation will meet the long-term biological needs of the listed salmonid species. The federal agencies, together with other regional sovereigns, are currently evaluating alternative configurations for the FCRPS so that a judgement can be made in late 1999 about what action is necessary to avoid jeopardizing the listed stocks.

The long-term measures described in the 1995 RPA should result in similar reductions in mortality for Snake River chinook and Snake River steelhead. Both species currently experience similar effects of transportation from the Snake River and should respond similarly under a long-term operation that maximizes transportation. A comparison of survival rates estimated for juvenile chinook and steelhead in free-flowing reaches of the Snake River (Section VI) suggests that the two species will experience similar effects of drawdowns.

VIII.A.2. Evaluate Effects of the Proposed Or Continuing Action in the Context of the Full Life Cycle to Determine If Species-Level Biological Requirements Are Likely to Be Met (V.D.2)

As described in Section V and Section VI.A.4, life-cycle analyses that estimate the probability of survival and recovery of Snake River steelhead are not possible at this time. The interim analysis applied in this supplemental opinion was described in previous sections but is summarized again here because it is a necessary departure from the analysis performed for the 1995 FCRPS Biological Opinion.

The interim analysis assumes that the smolt-to-adult (SAR) survivals of Snake River spring/summer chinook and Snake River steelhead during a historical period correspond to survival rates that represent acceptable probabilities of survival and recovery. The assumption that historical SAR rates can be used as a proxy for acceptable probabilities of survival and recovery has been partially validated for Snake River spring/summer chinook salmon by PATH (Marmorek et al. 1998 - Draft Report). However, this assumption has not been validated for steelhead.

A second assumption of this methodology is that, because the proposed action (including long-term measures, assumptions about survival changes in other parts of the life cycle, and assumptions about climate variability) has been determined to result in acceptable probabilities of survival and recovery, the proposed action can be assumed to result in a survival change sufficient to bring recent Snake River spring/summer chinook SARs to the historical target SAR level.

The third assumption of this methodology is that the incremental change between current and target historical Snake River steelhead SAR level is equal to or less than the incremental change necessary for Snake River spring/summer chinook salmon.

The preliminary conclusions of the interim analysis described in Section VI.A.4 indicate that the incremental change in SARs necessary for steelhead is less than or equal to that necessary for Snake River spring/summer chinook salmon, which supports the third assumption. When this information is combined with conclusions of VIII.A.1, which indicate that survival effects within the action area will be the same or greater for Snake River steelhead than for Snake River spring/summer chinook salmon, it appears that the proposed action is likely to result in achievement of historical SARs for Snake River steelhead. Based upon the first assumption, this suggests that species-level biological requirements of Snake River steelhead are likely to be met under the proposed action.

The supplemental proposed action includes funding analytical work to improve upon the interim method for assessing the effects of the proposed action on the species-level biological requirements addressed in this supplemental opinion. These efforts should be timed to ensure the availability of an improved analytical method prior to reconsultation on this action after a decision is made regarding the long-term configuration of the FCRPS at the end of 1999.

VIII.A.3. Summary of Conclusions for Snake River Steelhead

The NMFS has determined that, based on the available information, the proposed operation of the FCRPS by the Action Agencies, as described in Section III.A, and the issuance of two Section 10 research and enhancement permits by NMFS in support of transportation and smolt monitoring, as described in Section III.B, is not likely to jeopardize the continued existence of Snake River steelhead. This conclusion is based upon consideration of the effect of the proposed actions, including cumulative effects, on biological requirements within the action area and throughout the life cycle, as summarized in Sections VIII.A.1 and VIII.A.2.

VIII.B. Upper Columbia River Steelhead

VIII.B.1. Determine Significance of the Aggregate Effect Upon the Particular Biological Requirements of the Listed Species in the Action Area (V.D.1)

As stated in Section V, the biological requirements of juvenile and adult Upper Columbia River steelhead and Snake River chinook species are the same within the action area. The same considerations for assessing effect of the proposed action on the biological requirements of Snake River steelhead within the action area apply to Upper Columbia River steelhead.

<u>Interim Actions to Reduce Mortality of Listed Fish and Support the Long-Term Decision</u>

The reductions in <u>juvenile inriver mortality</u> associated with the 1995 RPA and supplemental proposed action appear similar for the two species. This conclusion is based primarily upon side-by-side analyses of the survival of juvenile Snake River steelhead and Snake River spring/summer chinook salmon through various project routes and FCRPS reaches (Section VI). As described in Section VI.A.3.c.1)b), the best available information on the survival of juvenile Upper Columbia River steelhead through federal projects in the lower Columbia River is obtained by extrapolating estimates of reach survival from those measured for juvenile Snake River steelhead and by using site-specific passage estimates for lower Columbia River projects. Through most routes of passage, survival of Snake River steelhead and spring/summer chinook is very similar. Reach survival estimates are slightly lower for wild steelhead than for wild chinook, but are slightly higher for hatchery steelhead than for hatchery chinook. Estimates for both wild and hatchery fish are relevant for the Upper Columbia River steelhead ESU, because the listing includes Wells Hatchery fish. On balance, the information presented in Section VI indicates that the two species experience similar rates of inriver survival and similar incremental changes in rates of inriver survival resulting from implementation of the 1995 RPA and the supplemental proposed action.

The conclusion that the proposed action will result in similar incremental changes in inriver survival for both species is inferred from empirical studies in which juvenile passage routing, travel time, or survival of both species was examined concurrently, as described in Section VI. Simulation modeling to specifically quantify and compare the incremental survival changes in each species was not available from PATH. When the PATH steelhead analysis is complete, this conclusion will have to be re-examined in light of the new information. One PATH participant submitted a summary of simulation modeling results that purported to demonstrate that certain elements of the supplemental proposed action had either negligible or detrimental effects on Upper Columbia River steelhead survival (Anderson 1998), but this analysis has not been reviewed by PATH or incorporated into a complete PATH analysis, it did not appear to analyze the full 1995 RPA plus supplemental proposed actions, and it did not contrast incremental changes for steelhead and chinook salmon.

The conclusion described above applies only to juveniles remaining in the river during migration. When transportation is considered, it is unknown whether or not the incremental change in juvenile survival to below Bonneville Dam associated with the 1995 RPA and supplemental action is equivalent for the two species. A discussion of relevant considerations for each species follows.

For Snake River spring/summer chinook, survival of fish transported from Snake River projects appears to be higher than inriver survival (Appendix B), although concerns raised by the ISAB and others have led to "spread-the-risk" management in which the proportion of migrants collected for transportation is restricted by spill at the three Snake River collector projects. Transport from McNary Dam prior to implementation of the 1995 RPA had a minor effect on this species because few Snake River spring/summer chinook remain in the river at McNary Dam (e.g., Schiewe 1998), and as summarized in 1995 RPA Measure 4, transport survival studies showed no clear benefits of transporting yearling chinook from this project. The incremental changes in survival due to interim measures in the 1995 RPA affecting transportation appear to be minor for spring/summer chinook salmon when compared with benefits from transportation in the years prior to the implementation of the 1995 RPA. The primary interim measures directly related to transportation survival are the addition of new barges to reduce holding times in raceways and the enlargement of barge exits. Improvements in collection efficiency have largely been offset by increased spill in most years. On balance, there is probably little or no incremental increase in survival of juvenile Snake River spring/summer chinook as a result of interim measures in the 1995 RPA related to transportation.

For Upper Columbia River steelhead, it is unknown whether transportation from McNary Dam was beneficial, detrimental, or had no effect during recent years prior to implementation of the 1995 RPA because evaluations were conducted under conditions that are no longer in existence (Appendix B). The NMFS believes that it is likely that transportation from McNary Dam was beneficial for steelhead during most of the period affecting the current status of the stock, based on results of studies conducted through 1980, but the lack of recent studies is a matter of great concern. Also of concern are PIT-tag detections in 1994, the last year in which spring migrants were collected for transportation at McNary. These data indicate that fish transported from this project survived at much lower rates than fish transported from other projects. Further studies are required to assess this situation before resuming transportation from McNary Dam. On balance, it is unknown whether elimination of transportation from McNary Dam in the 1995 RPA represents an increase, decrease, or no change in survival for Upper Columbia River steelhead when compared with pre-1995 RPA operations. An increase or no change would be equivalent to the survival change for Snake River spring/summer chinook; however, a decrease would not be equivalent.

Indirect mortality of juveniles below Bonneville Dam resulting from passage through the FCRPS and estuarine and ocean mortality resulting from federal water management is undetermined for either species, but is the subject of ongoing analyses by the PATH analytical team (Marmorek et al. 1998 - Draft Report). Until these analyses are completed, NMFS assumes that changes in indirect passage mortality and downstream mortality related to federal water management, if any, is similar for the two species.

Adult passage mortality of both Upper Columbia River steelhead and Snake River chinook through lower Columbia River projects is very similar for the two species, as described in Section VI, so both species are likely to have similar changes in adult survival as a result of the proposed action.

The timing and geographical range of measures to reduce FCRPS mortality appear to be sufficient for similar protection of juvenile steelhead, compared to protection of juvenile Snake River spring/summer chinook salmon. For example, the Action Agencies have proposed a mid-Columbia flow objective for the period April 10 to June 30 to match available water to the timing of smolt migration for this species.

Long-Term Major Structural Improvements to the FCRPS

Currently available information is not sufficient to conclude that the interim operation will meet the long-term biological needs of the listed salmonid species. The federal agencies, together with other regional sovereigns, are currently evaluating alternative configurations for the FCRPS so that a judgement can be made in late 1999 about what action is necessary to avoid jeopardizing the listed stocks.

The long-term drawdown measures at lower Snake River projects, described in the 1995 RPA, will not affect the survival of Upper Columbia River steelhead (unless accompanied by significant changes in water quality or quantity in the lower Columbia River). In this Supplemental Biological Opinion, the Action Agencies provide a comparable long-term action which will affect Upper Columbia River steelhead by including a commitment to evaluate alternatives for the long-term operation of FCRPS projects on the lower Columbia River. The feasibility study (described in Section III.A.4) will analyze the potential survival benefits to steelhead of alternative configurations including natural river drawdowns, maximum spill with gas abatement, full flow bypass of juveniles without handling, surface bypass collection, and improved transportation. As described in Section VI.A.3.c.1)b), similar survival of chinook and steelhead in free-flowing river sections and in transportation suggest that Snake River chinook and Upper Columbia River steelhead should experience similar changes in survival as a result of either the drawdown or maximum transportation long-term alternative action.

VIII.B.2. Evaluate Effects of the Proposed Or Continuing Action in the Context of the Full Life Cycle to Determine If Species-Level Biological Requirements Are Likely to Be Met (V.D.2)

The evaluation of the effects of the proposed action on the species-level biological requirements of Upper Columbia River steelhead is the same as that described in Section VIII.A.2 for Snake River steelhead. The preliminary conclusions of the interim analysis, described in Section VI.A.4, indicate that the incremental change in SARs necessary for Upper Columbia River steelhead is less than or equal to that necessary for Snake River spring/summer chinook salmon, supporting the third assumption set out in Section VIII.A.2 (above). To the extent that conclusions of VIII.B.1 indicate that survival changes within the action area will be similar for Upper Columbia River steelhead compared to Snake River spring/summer chinook salmon (i.e., conclusions relative to juvenile inriver survival and adult survival), it follows from the assumptions reviewed in VIII.A.2 that the proposed action is likely to result in achievement of historical SARs for Upper Columbia River steelhead. Based upon the first assumption, this suggests that species-level biological requirements of Upper Columbia River steelhead are likely to be met under the proposed action.

However, because the incremental Upper Columbia River steelhead juvenile survival change associated with eliminating transportation at McNary Dam is unknown, there is still some uncertainty regarding this conclusion. Another uncertainty that affects conclusions relative to species-level biological requirements involves the effects of other activities subject to ESA Section 7 consultation. When NMFS considers the effects of the action under consultation, here those of the FCRPS, it does so in the context of the entire life cycle for the listed stock. For activities in other life stages or other portions of the action area, NMFS projects a level of effects for those activities that would comply with the ESA, either Sections 7, 9 or 10. Therefore, for the Mid-Columbia projects, NMFS presumes that the Federal Energy Regulatory Commission (FERC) will comply with the procedural and substantive requirements of Section 7. That consultation is under way. Thus, the determination that FCRPS actions are not likely to jeopardize listed species will be consistent with similar determinations across the life cycle of the listed stock which, taken in combination, will insure that the continued existence of the listed species is not likely to be jeopardized.

Uncertainty in conclusions, particularly as they relate to effects of transportation on this species and the proposed actions and their effects in other parts of the life cycle, underscores the need for conclusions of this consultation to be considered of very limited duration. This species was listed less than a year ago and has not been the subject of intense research and ESA consultation, unlike Snake River chinook to which Snake River steelhead can be compared. During the two years in which conclusions of this consultation are in effect, the emphasis will be to gather additional information relevant to completing a more informed biological opinion regarding long-term configuration and operation of the FCRPS.

The supplemental proposed action includes funding analytical work to improve upon the interim method for assessing the effects of the proposed action on the species-level biological requirements addressed in this supplemental opinion. These efforts should be timed to ensure the availability of an improved analytical method prior to reconsultation on this action to support decisions on long-term measures, both at FCRPS projects in the lower Columbia River and the long-term operation and at non-federal PUD projects in the Columbia River above Priest Rapids Dam.

While there is uncertainty in assessing effects of the proposed action on meeting biological requirements, NMFS concludes that the proposed action is not likely to jeopardize listed Upper Columbia River steelhead. This conclusion is based on the interim analysis, which suggests that biological requirements will be met for juvenile inriver migrants and for adults, on required experimentation to attempt to resolve apparent survival problems associated with spring transportation from McNary Dam, required development of more refined analytical techniques, and anticipation of completion of other limited-duration biological opinions that will better define mortality in other life stages.

VIII.B.3. Summary of Conclusions for Upper Columbia River Steelhead

The NMFS has determined that, based on the available information, the operation of the FCRPS by the Action Agencies, as described in Section III.A, and the issuance of two Section 10 research and enhancement permits by NMFS in support of transportation and smolt monitoring, as described in Section III.B, is not likely to jeopardize the continued existence of Upper Columbia River steelhead. This conclusion is based upon consideration of the effect of the proposed actions, including cumulative effects, on biological requirements within the action area and throughout the life cycle, as summarized in Sections VIII.B.1 and VIII.B.2.

VIII.C. Lower Columbia River Steelhead

VIII.C.1. Determine Significance of the Aggregate Effect Upon the Particular Biological Requirements of the Listed Species in the Action Area (V.D.1)

As stated in Section V, biological requirements of juvenile and adult Lower Columbia River steelhead and Snake River chinook species are the same within the action area. The same considerations for assessing effect of the proposed action on Snake River steelhead action-area biological requirements apply to Lower Columbia River steelhead.

<u>Interim Actions to Reduce Mortality of Listed Fish and Support the Long-Term Decision</u>

Reductions in FCRPS mortality for Lower Columbia River steelhead are expected to result from elements of the 1995 RPA and supplemental proposed action that affect passage through Bonneville Dam and reservoir and that affect federal water management. As described in Section VI.A.3.c.1)b), the best available information for survival of juvenile Lower Columbia River steelhead through Bonneville Dam and pool is obtained by extrapolating estimates of reach survival from those measured for juvenile Snake River steelhead and by using site-specific passage estimates developed for Bonneville Dam. Changes in survival resulting from the proposed actions are expected to be similar for each species and absolute survival through the FCRPS is clearly higher for this species than for Snake River chinook salmon (at most, one project is passed).

Indirect mortality below Bonneville Dam resulting from passage through the FCRPS and estuarine and ocean mortality resulting from federal water management is undetermined for either species, but is the subject of ongoing analyses by the PATH analytical team (Marmorek et al. 1998 - Draft Report). Until these analyses are completed, NMFS assumes that changes in indirect passage mortality and downstream mortality related to federal water management, if any, is similar for the two species.

As described in Section VI, adult passage mortality rates for both steelhead and chinook through Bonneville Dam are very similar for the two species so it is likely that the proposed action will result in similar changes in adult survival rates.

The timing and geographical range of measures to reduce FCRPS mortality are expected to provide similar levels of protection for juvenile steelhead and juvenile Snake River spring/summer chinook salmon. Supplemental measures to reduce hydrosystem mortality will be implemented under the proposed action.

Long-Term Major Structural Improvements to the FCRPS

Lower Columbia River steelhead pass no more than one FCRPS project. Therefore, neither transportation nor future drawdowns are indicated as necessary to ensure their survival through the FCRPS.

VIII.C.2. Evaluate Effects of the Proposed Or Continuing Action in the Context of the Full Life Cycle to Determine If Species-Level Biological Requirements Are Likely to Be Met (V.D.2)

An analysis of effects of the proposed action on species-level biological requirements of Lower Columbia River steelhead was not possible for this supplemental Biological Opinion. In addition to a lack of tools for performing such an assessment, a much smaller part of the life-cycle of this ESU is influenced by FCRPS activities, compared to the other ESUs considered in this biological opinion. Therefore, knowledge of likely changes in actions affecting other parts of the life cycle is critical to performing a species-level analysis for Lower Columbia River steelhead.

In the absence of even an interim analytical method for quantifying the effect of the proposed action in the context of the life-cycle requirements of listed species, qualitative considerations lead to the conclusion that the proposed action is not likely to jeopardize Lower Columbia River steelhead. This conclusion is based on the following considerations: (1) only two of the stocks within this ESU pass any FCRPS projects, the remaining stocks pass none; (2) these two stocks pass only one project, resulting in much lower FCRPS mortality than that experienced by Snake River chinook stocks which are not jeopardized by the proposed action; and (3) the proposed action contains several measures specific to Bonneville Dam that are designed to reduce mortality both in the interim and long-term periods and therefore to reduce the effects of the environmental baseline for this species. The supplemental proposed action includes funding a committee to continue analytical work to develop a method that can be used to quantitatively assess the effects of the proposed action on the species-level biological requirements of this ESU. Timing of this measure should ensure the availability of an improved analytical method prior to reconsultation on this action.

VIII.C.3. Summary of Conclusions for Lower Columbia River Steelhead

The NMFS has determined that, based on the available information, the operation of the FCRPS by the Action Agencies, as described in Section III.A, and the issuance of two Section 10 research and enhancement permits by NMFS in support of transportation and smolt monitoring, as described in Section III.C, is not likely to jeopardize the continued existence of Lower Columbia River steelhead. This conclusion is based upon consideration of the effect of the proposed actions, including cumulative effects, on biological requirements within the action area and throughout the life cycle, as summarized in Sections VIII.B.1 and VIII.B.2.

IX. CONSERVATION RECOMMENDATIONS

Conservation recommendations are discretionary measures suggested to minimize or avoid the potential adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, to develop additional information, or to assist the federal agencies in complying with the obligations under section 7(a)(1) of the ESA. The NMFS believes the following conservation recommendations, supplemental to those stated in the 1995 FCRPS Biological Opinion, are consistent with these obligations, and therefore supports their implementation by the Action Agencies.

<u>Hydro-Regulation Analyses</u>:

> The Action Agencies should continue and, as appropriate, extend efforts to provide information and common analytical methods that will allow the regional fish and wildlife managers to evaluate alternative system operations and their associated costs in a timely manner.

The Memorandum of Agreement concerning BPA's financial commitment for Columbia River Basin Fish and Wildlife Costs included provisions to develop and implement agreed upon and accessible common accounting methods for determining costs associated with system operations. As a step toward that commitment, the BPA and the Northwest Power Planning Council have now developed a Hydro regulation model that runs on a PC platform. The BPA and the Council are making this model available to users in the region and will develop arrangements to ensure that the model is kept current and available to potential users in the region. Technical workshops on the use of the model are planned that will allow others in the region to become skilled, if they so desire. The BPA has made funds available to each tribe in the basin which may be used to assist them in gaining technical skills, among other things.

Equally important to understanding the costs of system operations is the underlying economic analysis. Several parties in the region are engaged in developing analytic tools. The BPA has developed a simplified economic spreadsheet model for determining the impacts of non-power requirements including fish measures. This model was made available to the public during April. The Power Planning Council, through its work on stranded costs, is also developing tools that may be useful for estimating costs associated with operating the system. The Corps of Engineers, through its Lower Snake River Feasibility Study, is examining an additional tool that may provide insights to the costs of system operations.

Continued progress in the development of mutual understandings concerning assumptions and analytical methods used to project costs and power losses associated with structural and operational changes in the FCRPS projects is essential to building trust and accountability in the planning and inseason management process.

Improved Flow

> The Action Agencies, in coordination with the Regional Forum, should continue and expand efforts to increase the ability to meet flow requirements for salmon in the Snake and Columbia Rivers while minimizing negative impacts on, or providing benefits to, resident fish and wildlife.

The 1995 FCRPS Biological Opinion limited drafts at FCRPS storage reservoirs on an "interim" basis. Interim draft limits were intended to identify water that would be available for spring and summer flow augmentation while minimizing adverse effects on resident fish and wildlife and other reservoir purposes. In that FCRPS Biological Opinion, NMFS:

- Acknowledged the need for additional water to assist in achieving Snake and Lower Columbia flow objectives and thereby further reduce the mortality of listed salmon;
- Recommended that the Action Agencies more thoroughly investigate alternative operations for providing flow augmentation and the associated risks to other species; and
- Provided for an inseason management process to optimize the benefits of available water.

To date, the FCRPS has in most cases, met the minimum operations specified in the 1995 FCRPS Biological Opinion with respect to flow. Investigations of additional sources of water and alternative operations and of associated risks to reservoir species have lagged. Meanwhile, other species of salmonids have been listed and proposed for listing, progress toward recovery of listed sturgeon remains elusive, and the U.S. Fish and Wildlife Service has proposed to list bull trout in the Columbia River Basin. This Supplemental FCRPS Biological Opinion specifies an additional flow objective for the Columbia River above Priest Rapids Dam and adjusts the April date at which system reservoirs must achieve upper rule curve, but it does not add any additional volume of water for flow augmentation.

In view of these factors, it is important that efforts to secure additional water, while better integrating the needs of salmon and other fish and wildlife and other requirements for water management in the Columbia basin, be continued and expanded. The investigation should include efforts to increase the volume of water available for spring and summer flow enhancement and to improve upon existing management practices. Continued and expanded investigations of sources of additional water (including more formal risk assessments) are needed before the regional fish and wildlife managers can develop a multispecies approach to river regulation that will improve the survival of proposed and listed salmonids while minimizing adverse impacts on, or providing benefits for, resident fish (such as bull trout and sturgeon) and wildlife.

Examples of measures to be included in this investigation are:

- The effects of interim draft limits on resident fish and wildlife at FCRPS storage reservoirs;

- Operations to provide an additional one MAF from storage reservoirs in the upper Snake River basin;

- Operations to shape the runoff hydrograph to more closely resemble a more natural hydrograph;

- Improvements in the TMT management process;

- Limitations on power peaking operations at both mainstem dams and upstream storage reservoirs to minimize adverse effects on fish and wildlife;

- Development of other (non-hydropower) means to support power peaking in the region;

- Potential for reduced irrigation withdrawals;

- Potential benefits to all parties of operating Kootenay Lake to a higher elevation during spring and summer; and

- Canadian Treaty and non-Treaty storage reservoir operations.

<u>Additional Water From Grand Coulee Reservoir</u>

> The Action Agencies, in coordination with the Regional Forum, should coordinate with concerned parties to coordinate and implement a deeper interim draft limit at Grand Coulee Reservoir. A draft limit deeper than the present (interim) limit of 1,280 feet would make more water available for meeting the spring flow objective in the mid-Columbia for juvenile steelhead without reducing the water available for summer migrants.

This would constitute an interim operation while the regional fish and wildlife managers conduct a system-wide assessment of the effects of alternative measures to meet flow objectives for steelhead on resident fish and wildlife, as described above (see “Improved Flow”).

X. REINIATION OF CONSULTATION

Consultation must be reinitiated if: the amount or extent of taking specified in the Incidental Take Statement is exceeded, or is expected to be exceeded; new information reveals effects of the action may affect listed species in a way not previously considered; the action is modified in a way that causes an effect on listed species that was not previously considered; or, a new species is listed or critical habitat is designated that may be affected by the action (50 CFR 402.16).

These general conditions apply as well to prospective agreements, plans and contracts ("prospective agreements") that the Action Agencies use to plan for operation of or to actually operate the FCRPS and to coordinate operations with Canada and regional utilities. Examples include implementation of the Columbia River Treaty (Treaty) between the United States and Canada, such as by the adoption of assured operating plans and detailed operating plans; arrangements with Canada for Non-Treaty storage; and renewing and revising the Pacific Northwest Coordination Agreement.

To the extent that the prospective agreements are used to achieve operations that are in accordance with this Supplemental FCRPS Biological Opinion, including the reasonable and prudent measures and the terms and conditions, the effects of those prospective agreements on Snake River salmon have been considered in this Supplemental FCRPS Biological Opinion. To the extent that proposed agreements have effects on FCRPS operations that affect listed fish in ways not considered in the supplemental opinion, or have provisions that go beyond implementing the operations specified in the supplemental opinion, those proposed actions may require separate consultation or reinitiation of this consultation.

XI. REFERENCES

Adams, N.S., D. Rondorf, S. Evans, J. Kelly, and R. Perry. 1997. Behavior of radio-tagged juvenile chinook salmon and steelhead in the forebay of Lower Granite Dam as determined from fixed-site receiving stations. p. 4-1 through 4-66 In: N. Adams, D. Rondorf, E. Kofoot, M. Banach, and M. Tuell. Migrational characteristics of juvenile chinook salmon and steelhead in the forebay of Lower Granite Dam relative to the 1996 surface bypass collector tests. Report by U.S. Geological Survey and Nez Perce Tribe of Idaho to the U.S. Army Corps of Engineers, Project No. E-86930151.

Allendorf, F.W. 1975. Genetic variability in a species possessing extensive gene duplication: Genetic interpretation of duplicate loci and examination of genetic variation in populations of rainbow trout. Ph.D. Dis., University of Washington, Seattle, 98 p.

Anderson, J. 1998. A review of draft Supplemental Biological Opinion for 1998. Memorandum to L. Krasnow and B. Brown (NMFS), April 2, 1998, under cover of Pacific Northwest Project, 3030 W. Clearwater, Suite 205-A, Kennewick, Washington. 4 p.

Bell, M.C. 1990. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corp of Engineers, North Pacific Division, Portland, Oregon.

Berggren, T.J., and M. Filardo. 1993. An analysis of variables influencing the migration of juvenile salmonids in the Columbia River basin. North American Journal of Fisheries Management 13:48-63.

Bickford 1997. Historical hydroacoustic information for Wells Dam 1982 to 1996 and proposal for the operation of the Wells bypass system. Public Utility District No. 1 of Douglas County, East Wenatchee, Washington.

Biological Requirements Work Group (BRWG). 1994. Memorandum for IDFG et al. v. NMFS et al. Principals regarding issues for discussion during September 26, 1994, conference call. Dated September 21, 1994. 2 p. + attachments.

Bjornn, T., and C. Peery. 1992. A review of literature related to movements of adult salmon and steelhead past dams and through reservoirs in the lower Snake River. U.S. Fish and Wildlife Service, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho.

Bjornn, T.C., J.P. Hunt, K.R. Tolotti, P.J. Keniry, R.R. Ringe. 1994. Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries - 1992. Report prepared for U.S. Army Corps of Engineers, Walla Walla District, and U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon. 128 p.

Bjornn, T.C., J.P. Hunt, K.R. Tolotti, P.J. Keniry, R.R. Ringe. 1995. Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries - 1993. Report prepared for U.S. Army Corps of Engineers, Walla Walla District, and U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon. 228 p.

Bjornn, T.C., R.R. Ringe, K.R. Tolotti, P.J. Keniry, J.P. Hunt, C.J. Knutsen, and S.M. Knapp. 1992. Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries - 1991. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, ID 83843 and Oregon Department of Fish and Wildlife, Portland Oregon. Prepared for U.S. Army Corps of Engineers, Walla Walla District. 55 p. + appendices.

Bonneville Power Administration (BPA). 1992. Stock summary reports for Columbia River anadromous salmonids, 5 volumes. Columbia River Coordinated Information System (CIS). U.S. Department of Energy, Bonneville Power Authority, Portland, Oregon.

Brege, D., R. Absolon, B. Sandford, and D. Dey. 1994. Studies to evaluate the effectiveness of extended-length screens at The Dalles Dam, 1993. Report to U.S. Army Corps of Engineers, Delivery Order E96930030, 26 pages + appendices.

Buchanan and Moring 1986. Management problems with recycling of adult summer steelhead trout at Foster Reservoir, Oregon. Fish Commission of Oregon, Portland.

Buettner, E., and A. Brimmer. 1995. Smolt monitoring at the head of Lower Granite reservoir and Lower Granite Dam. Annual Report 1993. Report from Idaho Dept. of Fish and Game to Bonneville Power Administration, Project 83-823, Contract DE-BI79-83BP11631, 73 p.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-27. 261 p.

Chapman, D., C. Peven, T. Hillman, A. Giorgi, and F. Utter. 1994. Status of summer steelhead in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, Idaho. 235 p. + appendices.

Cooney, T. 1998. Mid-Columbia steelhead SAR estimates. Draft memorandum to C.Toole (NMFS) from National Marine Fisheries Service, Hydropower Program, Portland, Oregon. April 3, 1998. 3 p. + tables

Dawley, E.M., R. Ledgerwood, L. Gilbreath, and P. Bentley. 1996. Relative survival of subyearling chinook salmon that have passed Bonneville Dam via the spillway, First or Second Powerhouse bypass system or turbines and tailrace. Reserach summary incorporating information from several studies conducted at Bonneville Dam between 1987-1993 under various contracts. Prepared for U.S. Army Corps of Engineers, Portland District, Portland, Oregon. 10 p.

Dawley, E.M., L. Gilbreath, and E. Nunnallee. 1997. Relative survival of juvenile salmon passing through the spillway of The Dalles Dam, 1997. Abstract. In: U.S. Army Corps of Engineers, Anadromous Fish Evaluation Program, 1997 Annual Research Review. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Faler, M.P., L. Miller, and K. Welke. 1988. Effects of variation in flow on distribution of northern squawfish in the Columbia River below McNary Dam. North American Journal of Fisheries Management 8:30-35.

Fish Passage Center (FPC). 1988. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon. 112 p.

Fish Passage Center (FPC). 1991. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1992. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1993. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1994. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1995. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1996. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1997. Smolt monitoring program. Annual Report,. Fish Passage Center, Portland, Oregon.

Gessel, M.H., B.P. Sandford, and D.B. Dey. 1994. Studies to evaluate the effectiveness of extended-length screens at Little Goose Dam, 1993. Annual report to U.S. Army Corps of Engineers, Walla Walla District, Delivery Order E86920164, 17 p. + appendix.

Giorgi, A.E., T. Hillman, J. Stevenson, S. Hayes, and C. Peven. 1997. Factors that influence the downstream migration rates of juvenile salmon and steelhead through the hydroelectric system in the mid-Columbia River basin. North American Journal of Fisheries Management 17:268-282.

Giorgi, A. 1996. Spill effectiveness/efficiency: scoping the information. PATH Task 3.1.4a. Appendix 4 of Chapter 6. In: D. Marmorek (ed.) Plan for Analyzing and Testing Hypotheses (PATH): Final report on retrospective analyses for fiscal year 1996. ESSA Technologies Ltd., Vancouver, B.C., Canada.

Graves, R., and C. Ross. 1998. Estimate of the proportion of Snake River fish that were transported at Lower Granite, Little Goose, and Lower Monumental Dams in 1995-1997, Draft Report. May 4, 1998. National Marine Fisheries Service, Hydropower Program, Portland, Oregon. 9 p. + tables

Harmon, J., D. Kamikawa, B. Sandford, K. McIntyre, K. Thomas, N. Paasch, and G. Matthews. 1995. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1993. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. Report to U.S. Army Corps of Engineers. Contract DACW68-84-H0034. 37 p. + appendices.

Hassemer, P.F. 1992. Run composition of 1991-92 run-year Snake River summer steelhead measured at Lower Granite Dam. Idaho Department of Fish and Game, Boise, Idaho. National Oceanic and Atmospheric Administration. Award NA90AA-D-IJ718. Project 83-335.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Kendra, and D. Ortmann. 1985. Stock assessment of Columbia River anadromous salmonids. Volume II: Steelhead stock summaries. Stock transfer guidelines -- information needs. Final Report prepared for U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon. Contract DE-AI79-84BP12737, Project 83-335. 1032 p.

Hurson, D., and 16 co-authors. 1996. Juvenile fish transportation program, 1994 Annual Report.. U.S. Army Corps of Engineers, Walla Walla District. Walla Walla, Washington. 94 p. + appendices.

Huzyk, L. and H. Tsuyuki. 1974. Distribution of LDH-B" gene in resident and anadromous rainbow trout (Salmo gairdneri) from streams in British Columbia. Journal of the Fisheries Research Board of Canada 31:106-108.

Idaho Department of Fish and Game (IDFG). 1994. Documents submitted to the ESA Administrative Record for west coast steelhead by E. Leitzinger, 18 October 1994. Idaho Department of Fish and Game, Boise, Idaho.

Independent Scientific Advisory Board (ISAB). 1998. Response to questions of the Implementation Team regarding juvenile salmon transportation in the 1998 season. ISAB Report 98-2. National Marine Fisheries Service, Hydropower Program, Portland, Oregon. 21 p.

Independent Scientific Group (ISG). 1996. Return to the river: restoration of salmonid fishes in the Columbia River ecosystem. Northwest Power Planning Council, Portland, Oregon. Publication 96-6. 584 p.

Iwamoto, R., W. Muir, B. Sandford, K. McIntyre, D. Frost, J. Williams, S. Smith, and J. Skalski. 1994. Survival estimates for the passage of juvenile chinook through Snake River dams and reservoirs. Annual Report 1993. National Marine Fisheries Service, Northwest Fisheries Science Center, and University of Washington, Center for Quantitative Science. Report prepared for U.S. Department of Energy, Bonneville Power Administration, Project 93-29. 126 p. + appendices.

Iwamoto, R.N., and J. Williams. 1993. Juvenile salmonid passage and survival through turbines. Report to U.S. Army Corps of Engineers, Project E86920049. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 27 p.

Krasnow, L.D. 1998. Fish guidance efficiency (FGE) estimates for juvenile salmonids at lower Snake and Columbia River dams, Draft Report. April 3, 1998. National Marine Fisheries Service, Hydropower Program, Portland, Oregon.

Ledgerwood D.L., E.M. Dawley, L.G. Gilbreath, P.J. Bently, B.P. Sandford, and M.H. Schiewe. 1990. Relative survival of subyearling chinook salmon which have passed Bonneville Dam via the spillway or the Second Powerhouse turbines or bypass system in 1989, with comparisons to 1987 and 1988. Report prepared for U.S. Army Corps of Engineers, Contract E85890097. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 64 p. + appendices.

Ledgerwood, R.D., E. Dawley, L. Gilbreath, L. Parker, B. Sandford, and S. Grabowski. 1994. Relative survival of subyearling chinook salmon after passage through the bypass system at the First Powerhouse or a turbine at the First or Second Powerhouse and through the tailrace basins at Bonneville Dam, 1992. Report prepared for U.S. Army Corps of Engineers, Contract DACW57-85-H-001. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Liscom, K.L., G.E. Monan, and L. Stuehrenberg. 1979. Radio tracking studies relating to fallback at hydroelectric dams on the Columbia and Snake rivers. p. 39-53 In: Fifth Progress Report on Fisheries Engineering Research Program 1973-78. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Liscom, K., G. Monan, L. Stuehrenberg, and P. Wilder. 1985. Radio-tracking studies on adult chinook salmon and steelhead trout at lower Columbia River hydroelectric dams, 1971-77. NOAA Technical Memorandum NMFS F/NWC-81.

Liscom, K.L., L. Stuehrenberg, and G. Monan. 1978. Radio-tracking studies of spring chinook salmon and steelhead trout to determine specific areas of loss between Bonneville and John Day Dams, 1977. Report prepared for U.S. Army Corps of Engineers, Portland District, Contract DACW57-77-F-0238. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 33 p.

Long, C.W., F. Ossiander, T. Ruehle, and G. Matthews. 1975. Survival of coho salmon fingerlings passing through turbines with and without perforated bulkheads and of steelhead trout fingerlings passing through spillways with and without a flow deflector. Report prepared for U.S. Army Corps of Engineers, Contract No. DACW68-74-C-0113, 8 p. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 8 p.

Long, J.B., and L.E. Griffin. 1937. Spawning and migratory habits of the Columbia River steelhead trout as determined by scale studies. Copeia 31: 62.

Marmorek, D.R. (ed.), J.J. Anderson, L. Basham, D. Bouillon, T. Cooney, R. Deriso, P. Dygert, L. Garrett, A. Giorgi, O.P. Langness, D. Lee, C. McConnaha, I. Parnell, C.M. Paulsen, C. Peters, C.E. Petrosky, C. Pinney, H.A. Schaller, C. Toole, E. Weber, P. Wilson, and R.W. Zabel. 1996. Plan for Analyzing and Testing Hypotheses (PATH): Final Report. Retrospective analyses for fiscal year 1996. ESSA Technologies, LTD., Vancouver, B.C., Canada.

Marmorek, D.R. and C.N. Peters (eds). 1998. Plan for Analyzing and Testing Hypotheses (PATH): Preliminary decision analysis report on Snake River spring/summer chinook. Draft Report. ESSA Technologies, LTD., Vancouver, B.C., Canada. 92 p. + appendices

Martinson, R.D., R. Graves, R. Mills, and J. Kamps. 1997. Monitoring of downstream salmon and steelhead at federal hydroelectric facilities - 1996. National Marine Fisheries Service, Hydropower Program. Prepared for U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon. Project Number 84-014, Contract Number DE-AI79-85BP20733. 18 p. + appendices.

Matthews, G.M., S. Achord, J.R. Harmon, O.W. Johnson, D.M. Marsh, B.P. Sanford, N.N. Paasch, K.W. McIntyre, and K.L. Thomas. 1992. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1990. Annual Report prepared for U.S. Army Corps of Engineers. Contract No. DACW68-84-H-0034. National Marine Fisheries Services, Northwest Fisheries Science Center, Seattle, Washington. 52 p. + appendix.

Mathur, D., P. Heisey, and J. Skalski. 1997. ABSTRACT - Juvenile steelhead passage survival through a flow deflector spillbay versus a non-flow deflector spillbay at Little Goose Dam, Snake River, Washington. Abstract. In: U.S. Army Corps of Engineers, Anadromous Fish Evaluation Program, 1997 Annual Research Review. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

McComas, R., D. Brege, W. Muir, B. Sandford, and D. Dey. 1993. Studies to determine the effectiveness of extended-length submersible bar screens at McNary Dam, 1992. Report prepared for U.S. Army Corps of Engineers, Delivery Order E86910060. National Marine Fisheries Service, Seattle, Washington. 34 p. + appendices.

McEwan, D. and T.A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California. 234 p.

Mesa, M.G. & T.M. Olson. 1993. Prolonged swimming performance of northern squawfish. Transactions of the American Fisheries Society 122:1104-1110.

Monan, G.E. and K.L. Liscom. 1975. Radio-tracking studies to determine the effect of spillway deflectors and fallback on adult chinook salmon and steelhead trout at Bonneville Dam, 1974. Final Report prepared for U.S. Army Corps of Engineers. Contract No. DACW54-74-F-0122. National Marine Fisheries Service, Coastal Zone and Estuarine Studies, Seattle, Washington.

Monan, G.E. and K.L. Liscom. 1976. Radio-tracking studies of summer chinook salmon and steelhead trout at and between Bonneville and The Dalles Dam, 1975. Report prepared for U.S. Army Corps of Engineers. Contract No. DACW-57-75-F-0548. National Marine Fisheries Service, Coastal Zone and Estuarine Studies, Seattle, Washington. 51 p.

Muir, W.D., S. Smith, R. Iwamoto, D. Kamikawa, K. McIntyre, E. Hockersmith, B. Sandford, P. Ocker, T. Ruehle, J. Williams, and J. Skalski. 1995. Survival estimates for the passage of juvenile chinook salmon through Snake River dams and reservoirs, 1994. Annual Report prepared for U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon. Project Number 93-29, Contract Number DE-AI79-93BP10891. 187 p.

Muir, W.D., S. Smith, K. McIntyre, and B. Sandford. 1997. ABSTRACT - Project survival of juvenile salmonids passing through the bypass system, turbines, and spillways with and without flow deflectors at Little Goose Dam. Abstract. In: U.S. Army Corps of Engineers, Anadromous Fish Evaluation Program, 1997 Annual Research Review. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Mullan, J.W., K.R. Willians, G. Rhodus, T.W. Hillman, and J.D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. Monograph I, U.S. Fish and Wildlife Service, P.O. Box 549, Leavenworth, Washington. 489 p.

National Research Council (NRC). 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C. 452 p.

National Marine Fisheries Service (NMFS). 1995a. Proposed recovery plan for Snake River salmon. National Marine Fisheries Service, Protected Resources Division, Portland, Oregon.

National Marine Fisheries Service (NMFS). 1995b. Basis of minimum flow ranges for operation of the Federal Columbia River Power System. National Marine Fisheries Service, Hydropower Program, Portland, Oregon. 13 p. + graphs.

National Marine Fisheries Service (NMFS). 1996. Factors for decline. A supplement to the Notice of Determination for West Coast steelhead under the Endangered Species Act. National Marine Fisheries Service, Protected Species Branch, Portland, Oregon. 83 p.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

Normandeau Associates, Mid-Columbia Consulting, and J.R. Skalski. 1996. Fish survival in passage through the spillway and sluiceway at Wanapum Dam on the Columbia River, Washington. Prepared for Grant County Public Utilities District by Normandeau Associates, Drumore, Pennsylvania.

Normandeau Associates, Inc., and J. Skalski. 1997. Turbine passage survival of chinook salmon smolts at the Rock Island Dam powerhouse I and II, Columbia River, Washington. Draft report prepared by Normandeau Associates for Public Utility District No. 1 of Chelan County, Wenatchee, Washington. 20 p.

Okazaki, T. 1984. Genetic divergence and its zoogeographical implications in closely related species Salmo gairdneri and Salmo mykiss. Japanese Journal of Ichthyology 31:297-310.

Olson, F.W., and V. Kaczynski. 1980. Survival of downstream migrant coho salmon and steelhead through bulb turbines. Prepared by CH2M Hill for Public Utility District No. 1 of Chelan County, Wenatchee, Washington. 45 p.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77:118-125.

Parkinson, E.A. 1984. Genetic variation in populations of steelhead trout (Salmo gairdneri) in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 41:1412-1420.

Paulsen, C., and A. Giorgi. 1998. Observations regarding the steelhead SAR analysis. Memorandum to C. Toole (NMFS) from Paulsen Environmental Consultants, Lake Oswego, Oregon. March 24, 1998. 14 p. + figures.

Petrosky, C.E. 1998a. Snake River SAR - FGE sensitivity. Memorandum to C. Toole (NMFS) and others, including attached spreadsheet STFGESEN.XLS, from Idaho Department of Fish and Game, Boise, Idaho, date April 3, 1998. 1 p. + attachments

Petrosky, C.E. 1998b. Smolt-to-adult return rate estimates of Snake River aggregate wild and hatchery steelhead. Draft Report for PATH Review, February 13, 1998. Idaho Dept. of Fish and Game, Boise. 6 p. + attachments

Petrosky, C.E., H. Schaller, and O. Langness. 1998. Untitled memorandum to C. Toole, T. Cooney, and J. Williams (NMFS), J. Gieselman (BPA), and C. Paulsen and A. Giorgi (consultants) regarding comments on March 24, 1998, memo from Paulsen and Giorgi on steelhead SAR. April 7, 1998.

Petrosky, C.E., and H. Schaller. 1998. Smolt-to-adult return rate estimates of Snake River aggregate wild spring and summer chinook. Draft Report for PATH review, March 31, 1998. Idaho Department of Fish and Game, Boise, Idaho. 6 p. + tables and figures

Peven, C.M. 1990. The life history of naturally produced steelhead trout from the mid-Columbia River Basin. M.S. Thesis, University of Washington, Seattle, Washington. 96 p.

Raymond, H.L. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer chinook salmon and steelhead in the Columbia River basin. North American Journal of Fishery Management 8:1-24.

Reiman, B.E., R. Beamesderfer, S. Vigg, and T. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 448-458.

Reisenbichler, R.R., J.D. McIntyre, M.F. Solazzi, and S.W. Landino. 1992. Genetic variation in steelhead of Oregon and northern California. Transactions of the American Fisheries Society 121:158-169.

Ross, C.V. 1998. Estimated survival of adult spring, summer and fall chinook, and adult summer and fall steelhead between lower Columbia dams based on radio tracking studies. Memorandum to NMFS Coordination Files. May 1, 1998. National Marine Fisheries Service, Hydropower Program, Portland, Oregon.

Ross, C.V. 1983. Evaluation of adult fish passage at Bonneville Dam, 1982. Fisheries Field Unit Report. U.S. Army Corps of Engineers, Portland District, Portland, Oregon. 101 p.

Schiewe, M.H. 1997a. Status review update for deferred and candidate ESUs of west coast steelhead. Memorandum to W. Stelle (NMFS) and W. Hogarth (NMFS), transmitting the

Biological Review Team Report. December 18, 1997. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 61 p.

Schiewe, M.H. 1997b. 1997 preliminary survival results for PIT-tagged juvenile salmonids. Memorandum to W. Stelle (NMFS). August 25, 1997. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 4 p.

Schiewe, M.H. 1998. Estimation of percentages of listed steelhead smolts arriving at McNary Dam in 1998. Memorandum to N. Chu (NMFS). March 2, 1998. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 18 p.

Schreck, C.B., H.W. Li, R.C. Hjort, and C.S. Sharpe. 1986. Stock identification of Columbia River chinook salmon and steelhead trout. Final Report prepared for U.S. Department of Energy, Bonneville Power Administration. Contract DE-A179-83BP13499, Project 83-451. 184 p.

Scott, C. 1985. Theoretical strike methodology. Memorandum to NMFS. December 5, 1985. National Marine Fisheries Service, Portland, Oregon.

Smith, S.G. 1998. Fish guidance efficiency (FGE) for natural and hatchery steelhead: information provided by PIT-tag data 1993-1997. March 6, 1998. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 4 p.

Smith, S.G., W. Muir, E. Hockersmith, S. Achord, M. Eppard, T. Ruehle, J. Williams, and J. Skalski. 1998. Survival estimates for the passage of juvenile salmonids through Snake River dams and reservoirs, 1996. Annual Report prepared for U.S. Department of Energy, Bonneville Power Administration, Contract DE-A179-93BP10891, Project 93-29. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 197 p.

Spurgeon, W., and 16 co-authors. 1997. Juvenile fish transportation program. 1996 Annual Report. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. 109 p. + appendices.

Steig, T.W. 1994. Review of spring and summer spill effectiveness for juvenile salmon and steelhead at various Columbia and Snake River dams, 1983-1992. Thirteenth Annual Symposium of the North American Lake Management Society, Seattle, Washington, November 29 - December 4, 1993. Lake and Reservoir Management 9(1): 154-162.

Technical Advisory Committee (TAC), *U.S. versus Oregon*. 1997. 1996 all-species review, Columbia River fish management plan. August 4, 1997. U.S. Fish and Wildlife Service, Vancouver, Washington.

Turner, A.R., J.R. Kuskie and K.E. Kostow. 1984a. Evaluations of adult fish passage at Ice Harbor and Lower Monumental dams, 1982. U.S. Army Corps of Engineers, Portland District, Portland, Oregon. 66 p. + appendices.

Turner, A.R., D.M. Shew, L.M. Beck, R.J. Stansell, and R.D. Peters. 1984b. Evaluation of adult fish passage at Bonneville Lock and Dam in 1983. U.S. Army Corps of Engineers, Portland District, Portland, Oregon. 90 p.

Utter, F.M., and F.W. Allendorf. 1977. Determination of the breeding structure of steelhead populations through gene frequency analysis. In: T. J. Hassler and R. R. VanKirk (ed.), Proceedings of the Genetic Implications of Steelhead Management Symposium, May 20-21, 1977, Arcata, California, p. 44-54. California Cooperative Fishery Research Unit Special Report 77-1.

Vigg, S., and C. Burley. 1991. Temperature-dependent maximum daily consumption of juvenile salmonids by northern squawfish (Ptychocheilus oregonensis) from the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 48: 2491-2498.

Wagner, E. and P. Ingram. 1973. Evaluation of fish facilities and passage at Foster and Green Peter Dams on the South Santiam River drainage in Oregon. Fish Commission of Oregon, Management and Research Division. U.S. Army Corps of Engineers, Portland District, Portland, Oregon. Contract No.DACW57-68-C-0013.

Weitkamp, D.E., D. McKenzie, and T. Schadt. 1980. Survival of steelhead smolts - Wells Dam turbines and spillway, 1980. Processed Report. Public Utility District No. 1 of Douglas County, East Wenatchee, Washington. 39 p.

West Coast Steelhead Biological Review Team. 1997. Status review update for west coast steelhead from Washington, Idaho, Oregon, and California. 7 July 1997. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 68 p.

Whitney, R.R., L. Calvin, M. Erho, and C. Coutant. 1997. Downstream passage for salmon at hydroelectric projects in the Columbia River basin: development, installation, and evaluation. U.S. Department of Energy, Northwest Power Planning Council, Portland, Oregon. Report 97-15. 101 p.

Whitt, C.R. 1954. The age, growth, and migration of steelhead trout in the Clearwater River, Idaho. M.S. Thesis, University of Idaho, Moscow, Idaho, 67 p.

Williams, J. 1998. Comments on the methodology used to derive age structure in the draft paper for PATH entitled "Smolt-to-adult return rate estimates of Snake River aggregate wild spring and summer chinook" by Petrosky and Schaller, dated 31 March 1998. Submitted to PATH April 3, 1998. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 5 p.

XII. INCIDENTAL TAKE STATEMENT

Section 9 and regulations implementing Section 4 of the ESA prohibit any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of listed species without a specific permit or exemption. When a proposed federal action is found to be consistent with Section 7 (a)(2) of the ESA (i.e., the action is found not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat) and that action may incidentally take individuals of listed species, NMFS will issue an incidental take statement specifying the impact of any incidental taking of endangered or threatened species.

The incidental take statement also provides reasonable and prudent measures that are necessary to minimize impacts, and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures. Incidental takings resulting from the agency action, including incidental takings caused by activities authorized by the agency, are exempted from the taking prohibition by Section 7(o) of the ESA, but only if those takings are in compliance with the specified terms and conditions.

This incidental take statement supplements the 1995 FCRPS Biological Opinion. The 1995 incidental take statement shall continue in full effect except to the extent that this supplemental incidental take statement changes particular measures or establishes additional measures.

The approximate mortality rate of upstream-migrating adult steelhead through FCRPS projects is not expected to exceed 21% for Snake River steelhead; five percent for Upper Columbia River steelhead; and four percent for Lower Columbia River steelhead. Mortality of downstream-migrating adults (kelts) resulting from operation of the FCRPS is unknown. Therefore, one of the following incidental take measures is intended to provide estimates of kelt mortality through the FCRPS. Although the expected rate of mortality of juvenile steelhead migrating through the FCRPS under interim operations and potential long-term configurations is unknown, for all three ESUs, juvenile mortality is expected to be approximately the same or less than that experienced by Snake River spring/summer chinook salmon (described in the 1995 FCRPS Biological Opinion).

A. TERMS AND CONDITIONS

The Action Agencies shall continue to coordinate through the Regional Forum the necessary evaluations and actions contained in the following terms and conditions of the ITS. If implementation of these terms or conditions is delayed or deferred, the Action Agencies and NMFS shall then determine whether further consultation is required through the Framework process set up by Reasonable and Prudent Alternative measure 26 of the 1995 FCRPS Biological Opinion. As a result of this determination, the terms and conditions may subsequently be modified.

1. Terms and conditions to reduce juvenile mortality.

1.a. The Action Agencies, in coordination with the Regional Forum, shall review the findings in the Columbia River Basin System Flood Control Review -- Preliminary Analysis Report (1997) and evaluate further steps to examine **flood control operations** (including the timing of operations and rule curves) in the Columbia River basin with the goal of increasing the probability of meeting spring period flow objectives for steelhead. The Action Agencies shall submit a report to NMFS and the Region by December 1998 on appropriate measures.

One example of an opportunity to use flood control releases to benefit steelhead is in the Snake River. Under current flood control practices, water held for flood control is often released during periods (i.e., during October or March) when it can provide relatively little benefit to migrating steelhead. If the timing of flood control releases could be changed to more closely coincide with juvenile fish movement (e.g., from March to April), this water would assist in meeting flow objectives and improve juvenile survival. In the Columbia Basin overall, a relaxation of flood control requirements (e.g., an increase in the target control flow from 450 to 550 kcfs at The Dalles), particularly in below average runoff years, would assist in meeting spring flow objectives and benefit migrating juveniles by allowing more water to pass inriver during the spring.

1.b. The Action Agencies, in coordination with the Regional Forum, shall cooperate in the efforts of the public utility districts to investigate the over-winter survival and **migrational timing of wild juvenile Upper Columbia River steelhead** to ensure sufficiency of the timing of the mid-Columbia River spring flow objective for all listed stocks. The findings of these investigations and recommended changes to the timing of the flow objective in this supplemental Biological Opinion that are merited by the study results, should be discussed in the Regional Forum and after determination by NMFS, appropriate changes to the timing of the mid-Columbia flow objective shall be implemented.

1.c. The Action Agencies, in coordination with the Regional Forum, shall cooperate in the efforts of the public utility districts to investigate the relationship between flow, travel time, and other related parameters and the **survival of wild juvenile Upper Columbia River steelhead** to ensure sufficiency of the magnitude of the mid-Columbia River spring flow objective for all listed stocks. Preliminary investigations are scheduled to begin in 1998, with a full study initiated in 1999. Findings of these investigations and recommended changes to the magnitude of the spring flow objective proposed in this supplemental Biological Opinion that are merited by study results should be discussed in the Regional Forum and, after determination by NMFS, appropriate changes to the magnitude of the spring mid-Columbia flow objective shall be implemented.

1.d. The Action Agencies, in coordination with the Fish Facility Design Review Work Group and the Fish Passage Improvement Through Turbines Technical Work Group, shall continue the program to study hydraulic and behavioral aspects of **turbine passage by juvenile**

steelhead and salmon through turbines for the purpose of developing biologically-based turbine design and operating criteria. The Action Agencies shall submit a report to NMFS stating the findings of the first phase of the Turbine Passage Survival Program by 2001.

These studies shall include evaluation of existing turbine designs including baseline survival studies as appropriate for each project, prototype turbine designs and modifications to the turbine environment (intake to draft tube exit) and shall consider whether these designs are likely to improve the survival of juvenile steelhead and other salmonids passing via the turbine route.

1.e. The Action Agencies shall design and implement a thorough investigation of the new **minimum gap runner at Bonneville Dam** First Powerhouse to ensure that the new runner environment provides improved survival for juvenile migrants that pass through turbines. The Action Agencies shall submit a report to NMFS stating the findings of these investigations by January 2001.

1.f. The Action Agencies, in coordination with the Regional Forum, shall utilize information from the ongoing turbine studies, including examination of minimum gap runners at Bonneville Dam, and consider turbine modifications to improve fish passage survival in the ongoing major rehabilitation program at **The Dalles Dam**. In the future, any **turbine rehabilitation program** shall consider state-of-the-art technology to decrease fish injury and mortality.

Regardless of fish screens and spill programs, a large proportion (20% or more) of migrating juvenile steelhead pass through the turbines at FCRPS dams. The installation of turbine passage modifications that are proven to improve juvenile survival will reduce hydrosystem loss of juvenile steelhead and other salmonids. Turbine modifications (intake to draft tube exit) shall be considered for McNary, John Day, and Bonneville Dams under the Feasibility Studies for Alternative System Configurations in the Lower Columbia River. These types of modifications shall also be considered in the ongoing rehabilitation program at The Dalles Dam.

1.g. The Action Agencies, in coordination with the Regional Forum, shall investigate the smolt-to-adult return rates (SAR) for listed steelhead and other salmonids that pass through **bypass systems at multiple projects**, compared to smolts with other passage histories. The Action Agencies, in coordination with the Regional Forum, shall develop a study plan, analytical protocol, and implementation schedule no later than October 1998, with the intent of initiating the study during the 1999 juvenile migration season. If indicated by study results, recommendations for reducing associated mortality shall be implemented as soon as possible after consultation with NMFS.

Recent adult PIT-tag recoveries and calculated smolt-to-adult return rates suggest that smolts detected passing through juvenile bypass systems at several projects may have lower survival than those which remain undetected or which are detected in bypasses at fewer projects. Because direct survival through bypasses is high, this suggests that indirect mortality may be associated with passage through bypasses. Because most listed smolts from the Snake and Upper Columbia River steelhead ESUs encounter one or more of these systems, it is crucial that they result in high direct and indirect passage survival. Adult PIT-tag detectors necessary for this study shall be installed at appropriate projects.

1.h. The Action Agencies, in coordination with the FPOM, shall install and maintain effective means of discouraging predation (e.g., water spray, avian predator lines) at all forebay, tailrace, and bypass outfall locations where **avian predator activity** has been observed at FCRPS dams. The Action Agencies shall work with FPOM and NMFS on recommendations for any additional measures and implementation schedules and report progress in the annual Facility Operating Reports to NMFS. After consultation with NMFS, corrective measures shall be implemented as soon as possible thereafter.

Bird predation marks are among the most common injuries observed on juvenile steelhead at smolt monitoring sites. During 1995 and 1996, 15% and 10%, respectively, of all the hatchery steelhead examined at John Day Dam exhibited bird predation marks (Martinson et al. 1997). These observations indicate a high rate of predation on juvenile steelhead which could be reduced with appropriate measures. The Action Agencies shall coordinate scoping and implementation of predator control measures with the USFWS to ensure that the measures to not endanger bald eagles, osprey, and other bird species that are afforded federal protection.

1.i. The Action Agencies, in coordination with the Regional Forum, shall investigate the **spillway passage survival** of juvenile salmonids at appropriate FCRPS dams. These investigations shall assess the effect of spill patterns and per bay spill volumes on fish survival, across a range of flow conditions. The Action Agencies shall develop a phased approach (including costs and schedules) and set priorities with NMFS through the Regional Forum to initiate, beginning in 2000, spillway passage survival studies.

Spillway passage has become an increasingly important route of passage for juvenile steelhead at FCRPS dams. These studies will ensure that each spillway is operated in a manner that results in the lowest possible direct and indirect mortality.

The ongoing spill study at The Dalles Dam will be completed during 1999, as described in the proposed action. As a requirement of that study, the Action Agencies shall ensure that a new, interim juvenile PIT-tag detector is installed at the Bonneville Dam Second Powerhouse in time for the 1999 steelhead outmigration.

1.j. The Action Agencies, in coordination with the Regional Forum, shall investigate the **efficacy of 24 hour spill at John Day Dam**. The study shall evaluate the effect 24 hour spill has on forebay residence time, spill efficiency and spill effectiveness for both spring and summer migrants. Adult passage considerations and potential adult fallback will be considered in the study design. The Action Agencies shall develop a study design in coordination with NMFS and the Regional Forum to initiate the study beginning in 1999.

> To maximize the information gained from this study and to minimize operational impacts, the study shall not exceed two years in duration, and shall involve the minimum number of "sample" days each week necessary to provide valid information on study objectives.

High spillway effectiveness and high daytime passage was noted during 24 hour spill in 1997. Effectiveness was highest during the summer but daytime passage was much higher than expected in both spring and summer, indicating a potential decrease in forebay residence time and subsequent predator exposure in this area. Because the 24 hour spill in 1997 was due to high river flows, a controlled evaluation was not possible. Such a test is necessary to see if the 1997 observations could be used to improve the John Day Dam spill scenario described in the proposed action.

1.k. The Action Agencies, in coordination with the Regional Forum, shall evaluate the **effect of spill duration and volume on spillway effectiveness** (percent of total project passage via spill) and **efficiency** (fish per unit flow) and forebay residence time of juvenile steelhead and salmon passing FCRPS dams. Studies will include the spring outmigration at collector projects and may include both spring and summer outmigrations at noncollector projects. Adult passage considerations and potential adult fallback will be considered in study designs. An overall study plan will be developed for a phased approach to address costs, schedules, and priorities among projects. To the extent that greater spill duration and/or volumes are required for the purposes of evaluation at some projects, every effort will be made to minimize or offset additional impacts to the power system. For instance, studies may be planned to take maximum advantage of periods when involuntary spill can be expected to occur with minimal additional sample days to evaluate the consistency of patterns at lower flow levels.

The purpose of this measure is to provide for the development of information necessary to ensure that project survival is sufficient to avoid jeopardy. Whereas the current nighttime spill regime is based on our understanding of hours of peak daily juvenile fish passage, it is clear that fish move throughout the day and that, as a result, longer spill hours may improve juvenile fish survival past the dams by increasing the proportion of fish passing in spill. There may also be operational changes associated with spill patterns or hourly project operations that influence the proportion of fish passed through spill. It may also be possible to reduce delay when fish first encounter the dam and thereby limit exposure to predation in project forebays. On the other hand, longer spill hours could have negligible or adverse biological impacts such as delay or fallback of adults or increased exposure to dissolved gas supersaturation. In addition, changes in project operation that increase the volume of water spilled and/or increase the duration of daily spill operations have a considerable effect on power operations. The intent of the efficiency and effectiveness information is to ensure that the use of current and future spill volumes is optimized as a means of achieving biological performance standards to avoid jeopardy. Any resulting changes in the annual operation will be coordinated through the Regional Forum process and memorialized through the 1995 RPA Measure 26 consultation Framework or some similar process and will consider the BPA's financial circumstances and its ability to finance such a change in operations.

Another reason to increase our knowledge of spill effectiveness is to allow more accurate estimates of smolt to adult returns (SAR) of PIT tagged fish released in the hydrosystem. Currently, it is difficult to estimate how many tagged juveniles pass through the spillway and turbines because PIT tags are only detected at bypass systems. SAR's can be determined for bypassed and non-bypassed fish but the non-bypassed component cannot be accurately split into spill and turbine estimates. More accurate spill effectiveness estimates would allow greater accuracy in estimating this split.

1.l. The Action Agencies, in coordination with the FPOM, shall begin **monitoring fish passage at Lower Granite Dam** no later than March 25 of each year

Based on monitoring data from years with variable start dates, the wild steelhead outmigration past Lower Granite Dam appears to begin during the last week of March. During the period 1985 through 1997 (omitting 1993, when monitoring did not begin until April 15), the mean date of arrival for daily index counts of 100 or more wild steelhead was April 3 (Fish Passage Center, Smolt Index Report and FTOT Annual Reports, NOAA). During 1996 and 1997, more than 100 steelhead were monitored on the start dates of March 27 and 28, respectively, and during 1997 more than 2,000 steelhead were observed on March 30. Monitoring must begin by March 25 of each year to provide full information about the wild component outmigration for use in inseason management and planning.

1.m. The Action Agencies, in coordination with the Regional Forum, shall initiate, during 1999, an **experimental evaluation of the smolt-to-adult survival of juvenile chinook and steelhead transported from McNary Dam**. Joint development and agreement on a transportation evaluation study plan by federal, state, and tribal managers is needed by the end of 1998 so that approved research can begin in 1999. At a minimum, objectives of the study shall include:

1) the absolute return rates of transport and in river groups;
2) the ratios of tranport:inriver return rates and their relationships to river conditions;
3) the effects of transportation from McNary on homing; and
4) relationships between ratios of transport:inriver return rates and measurements of juvenile survival below McNary Dam.

To ensure the success of this study, the Action Agencies shall install necessary adult PIT-tag detectors at FCRPS projects prior to the expected return of any adult steelhead from the 1999 outmigration.

NMFS' rationale for deciding not to resume spring transport operations from McNary Dam at this time stems from concerns identified in the review of adult return information from fish PIT-tagged in the Snake River during 1994 and subsequently transported from McNary Dam. These data suggest that there may be a previously undetected problem with fish that were collected at McNary Dam in the juvenile facility that became operational during 1994. The problem may affect all fish entering the bypass, not just those that are transported.

NMFS is also concerned with the lack of any recent information on transport from McNary Dam. In view of significant improvements in passage downstream of McNary, and the higher proportion of Snake River fish already being barged without additional transport from McNary, NMFS believes it prudent to approach any resumption of spring transport from McNary as a research experiment focused on the response of fish originating in the Columbia River above the confluence with the Snake River.

In their review of the juvenile fish transportation program, the ISAB (1998) suggested that the benefits of transportation are likely to vary between stocks within an ESU. Therefore, where possible, the benefit of transportation should be evaluated in terms of returns to the spawning grounds of experimental groups from known stocks rather than from the aggregate run.

1.n. The Action Agencies, in coordination with the Regional Forum, shall **evaluate transport:inriver return ratios** for steelhead marked at and transported from **Lower Granite Dam** during the 1999 smolt outmigration. If the 1999 decision for the long-term operation of FCRPS projects on the lower Snake River includes some continued reliance on transportation, the Action Agencies shall continue transport survival studies for both steelhead and chinook from Lower Granite Dam in future years.

The ISAB's recent independent peer review suggested that the use of smolt transportation as a tool to mitigate hydrosystem losses and to support the recovery of listed stocks should be considered experimental in the sense that the relative survival of transported fish should be continually monitored and reevaluated. At present, marking operations at dams provide the only certain method of obtaining statistically robust numbers of marked wild steelhead and chinook smolts for calculating comparative estimates of the survival of transported and inriver migrants. The Action Agencies shall install necessary adult PIT-tag detectors at appropriate projects.

2. Terms and conditions to reduce adult mortality.

2.a. The Action Agencies, in coordination with the FPOM, shall investigate the cause of **"headburn" in adult salmonids** and shall implement corrective measures, if appropriate. The Action Agencies shall review all available information relating to this subject and develop with NMFS, through the regional process, a study protocol, and conduct a study. The study protocol and any immediate recommendations for measures to reduce mortality due to headburn should be developed by October 1998. These recommendations should be implemented as soon as possible thereafter. Based on the findings of this study, appropriate measures to address this condition and a schedule for implementation should be developed in consultation with NMFS.

The proportion of adult salmonids with headburn has exceeded five percent at FCRPS dams since at least 1993. The cause of headburn is unknown as is the rate of survival of affected fish. However, the cause of headburn appears to be related to passage through the hydropower system and it is unlikely that many fish with this condition survive to spawn. The goal of these investigations shall therefore be to identify the cause and mechanism of headburn injury and to identify preventative measures, to be implemented after consultation with NMFS.

2.b. The Action Agencies in coordination with the Regional Forum, shall develop a study approach to evaluate dam passage rate and success (including **dam and system survival**) of adult steelhead returning to the ocean after spawning (**kelts**). The Action Agencies shall cooperate with NMFS and the region to develop detailed study plan, assign priorities and establish schedules and costs by October 1998. The detailed study plan will specify inclusion of a review of available literature regarding transportation of steelhead kelts as a possible means of reducing dam passage mortality.

Steelhead kelts comprised 28 and 48% of the adult wild steelhead fallback through the Smolt Monitoring Program sampler at John Day Dam during 1995 and 1996, respectively. Primary passage occurred during April through June. Although bypass systems are in operation during this period, we have no information on how well steelhead kelts pass through these systems.

2.c. To improve adult fishway operations, the Action Agencies, in coordination with the FPOM, shall:

1) develop means for the early detection of potential **diffuser grating failure** in adult collection channels and ladders ;
2) develop improved measures to ensure the security of diffuser gratings in adult fishways at all projects; and
3) **develop an Emergency Response Plan** for each FCRPS mainstem project, to be followed in the event that critical components of adult passage facilities break, washout or cease to operate.

The Action Agencies shall work through the Fish Passage Operations and Maintenance (FPOM) committee to implement, as appropriate, measures identified under paragraphs 2.c.1 and 2.c.2 above and incorporate emergency response protocols into the annual Fish Passage Plan prior to the 1999 fish passage season.

Due to a failure of the diffuser grating, the adult fishway at Bonneville Dam Second Powerhouse malfunctioned during July 1997. Although fish loss was low, it took several weeks to develop an action plan for (1) recovering trapped adults and (2) repairing the facility. A similar incident at

The Dalles Dam during 1994 resulted in hundreds of dead adult steelhead and chinook salmon (Memo for the Record dated January 18, 1994, Robert Dach, Corps of Engineers, Portland District). The condition stated above is intended to minimize the number of adult steelhead and other salmonids which might be lost during this type of malfunction.

2.d. The Action Agencies, in coordination with the Regional Forum, shall develop improved operations for **adult fishway main entrances** at FCRPS dams so that these entrances provide adult migrants the best possible attraction conditions when reservoir elevations are held at Minimum Operation Pool. The Action Agencies shall report the findings of these investigations and recommend corrective measures in a report to NMFS by 2000. The Action Agencies shall continue to work through FPOM to evaluate and implement, if appropriate, various operations (closed floating orifice gates or other operational alternatives) to improve adult entrance and passage facilities.

Some adult fish facilities at the lower Snake River FCRPS projects were not designed to operate under the Minimum Operating Pool (MOP) requirement set out in the 1995 FCRPS Biological Opinion. As a result, fish passage criteria are not always met. Therefore, the Action Agencies shall investigate methods of meeting operating criteria for adult facilities that are related to operation of these dams at MOP including hydraulic, mechanical, and electrical functioning of the auxiliary water supply pumps. Alternative structural measures shall consider the development of additional flows for the north shore ladder entrance at Lower Granite Dam.

2.e. The Action Agencies, in coordination with the Regional Forum, shall utilize information from previous and ongoing investigations regarding the problem of **adult steelhead holding** and jumping in the fish ladders at John Day Dam to develop a proposed course of action. The Action Agencies shall include the findings of these investigations and recommended corrective measures as part of the Lower Columbia River Feasibility Study report in 2000. These corrective measures shall be implemented as soon as possible thereafter, following consultation with NMFS.

Adult steelhead delay is also a problem at John Day Dam where hundreds of steelhead hold in the adult fish ladders in the mid- to late-fall period. This phenomenon has been well documented by the Corps' Fishery Field Unit. Several attempts have been made to remedy this situation including reducing the amount of area available for fish to hold in and altering local hydraulic conditions to lure fish out of the area. None of these measures has been very successful and steelhead continue to hold in these areas every year. One unfortunate result of this holding is that the fish jump in the ladder pools. Jumping can cause serious injury and fatigue and, in the past, has resulted in killing a number of steelhead each year. Currently, netting keeps the fish in the ladder, but the jumping continues and a better solution to the jumping problem must be found.

2.f. The Action Agencies, in coordination with the Regional Forum, shall investigate and implement measures to **reduce fallback mortality** of upstream migrant steelhead at all lower Snake and lower Columbia River dams. These measures may include the installation of extended-length screens and extending the period during which the juvenile bypass system is in operation, at dams which have these facilities. The Action Agencies shall use all available information to develop, with NMFS and the Regional Forum, a plan for optimizing adult passage and minimizing adverse effects. This could include supplemental studies if there are substantial data gaps. Initial recommendations and a schedule for completing the plan will be prepared by the FPOM committee by October 1998. Corrective measures shall be implemented as soon as possible, following consultation with NMFS.

Pre-spawn, summer run steelhead are abundant near McNary Dam during the late fall and early winter months. Fallback through the juvenile bypass system at McNary can exceed 50 steelhead per day during the period just prior to screen removal on December 15 (Paul Wagner, Washington Department of Fish and Wildlife, pers. comm.). Large concentrations of steelhead are also observed in late fall in the vicinity of John Day Dam. Therefore, there is reason to believe that fallback at McNary and John Day Dams could be high during the period when screens are normally removed. This term/condition of the incidental take statement supplements 1995 RPA Measure 8 to provide protection for steelhead during the winter portion of the adult migration.

2.g. The Action Agencies, in coordination with the Regional Forum, shall investigate the problem of attraction and delay of adult **fallbacks in specific parts of juvenile collection galleries** at Ice Harbor and McNary Dams. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending corrective measures and implementation schedules by 2001.

Adult steelhead are known to fallback and hold in collection channels at Ice Harbor and McNary Dams. In the past, some of these fish jumped out of the channels and died. Nets were installed to prevent this type of mortality. However, the adult steelhead continue to be injured as they jump against the nets. The goal of this term/condition of the Incidental Take Statement is to develop and implement further corrective measures that will reduce the injury and delay of adult steelhead.

2.h. The Action Agencies, in coordination with the Regional Forum, shall investigate measures to reduce adult steelhead and salmon **fallback and mortality rates through the Bonneville Dam spillway**. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending corrective measures either as part of the Lower Columbia River Study or in the form of a separate report to be completed by the same date. After consultation with NMFS, corrective measures shall be implemented as soon as possible.

Fallback at Bonneville Dam is a well known problem for adult steelhead and other salmonids that has been documented by several radio tracking studies (Monan and Liscom 1975, Ross 1983). Although a daytime spill cap at this project helps reduce adult fallback, it also decreases spillway passage effectiveness and the survival of juvenile steelhead and other salmonids. Resolution of this problem is one of the most important survival improvements that could be made for Bonneville Dam and for adult and juvenile steelhead passing through the lower Columbia River.

2.i. The Action Agencies, in coordination with the Fish Facility Design Review Work Group and the Fish Passage Improvement Through Turbines Technical Work Group, shall support the design and implementation of a program to improve the **survival of adult steelhead and salmon passage through turbines**. This program will include baseline passage and survival estimates and investigate hydraulic and behavioral aspects of turbine passage. This information will be used for the purpose of developing biologically-based turbine design and operating criteria. The Action Agencies shall submit a scoping document by October 1998 and develop a plan of action.

These studies shall include the evaluation of adult survival and injury mechanisms associated with passage through existing Kaplan turbines as well as the evaluation of prototype turbine designs and modifications to the turbine environment (intake to draft tube exit) and shall consider whether these designs are likely to improve the survival of adult steelhead and other salmonids passing via the turbine route.

2.j. The Action Agencies shall continue to implement **adult salmonid counting** programs at FCRPS dams but shall improve the reporting of these counts to NMFS. In addition to the daily counts already provided, the Action Agencies shall work through the Fish Program Operations and Maintenance Coordination Team to improve reporting of annual cumulative counts and a 10-year record of daily passage at each FCRPS project. Reporting improvements shall also include timely (i.e., within three days) winter passage counts for all projects where winter counting currently occurs. These changes in reporting methods shall be implemented no later than the 1999 migration.

Pre-spawn, summer run steelhead are abundant near McNary Dam during the late fall and early winter months. Fallback through the juvenile bypass system at McNary can exceed 50 steelhead per day during the period just prior to screen removal on December 15 (Paul Wagner, Washington Department of Fish and Wildlife, pers. comm.). Large concentrations of steelhead are also observed in late fall in the vicinity of John Day Dam and adult steelhead are known to pass Bonneville Dam all winter. The reporting requirements described above are designed to provide the level of information needed for decision-making during both normal and emergency fish passage management and consultation, especially during the winter maintenance period.

3. Terms and conditions to reduce adult and juvenile mortality

3.a. **Guidelines for turbine operations** within one percent of peak efficiency and turbine operating range tables in the Fish Passage Plan shall be updated before February 1 of each year, through the Fish Passage Operations and Maintenance Coordination Team, with assistance from the Turbine Working Group.

The operational characteristics of turbines are under continual review in model and field studies. New information, including data on the effects of operating turbines at peak efficiency on the survival of juvenile and adult steelhead, should be reviewed on an annual basis and incorporated into the Corps' Fish Passage Plan and operational guidelines.

3.b. The Action Agencies, in coordination with the Regional Forum, shall maintain juvenile and adult fish facilities within criteria identified and operate the project within operational guidelines contained in the Corps' **Fish Passage Plan**. The Action Agencies will consult with NMFS on the development of these criteria and operational guidelines prior to the start of each fish passage season (generally February 1).

Reasonable and Prudent Alternative Measure 7 in the 1995 FCRPS Biological Opinion addressed the need to operate adult fishways within the operating criteria established in the Corps' Fish Passage Plan. Because the implementation of this plan directly affects the survival of adult and juvenile steelhead, and because this plan is included, by reference, in the 1995 FCRPS Biological Opinion, the Action Agencies will consult with NMFS regarding the operations and criteria stated in each annual plan.

3.c. The Action Agencies, in coordination with the Regional Forum, shall investigate tailrace hydraulic conditions through **general model studies** to determine optimum **spill patterns** that will minimize juvenile retention time in spill basins and tailraces and minimize adverse conditions for adult passage at all dams where this has not already been done. The Action Agencies and NMFS, in coordination with the Regional Forum, shall identify objectives for spill pattern testing in existing general models, shall establish priorities for tests in 1999 and future years, and shall develop a schedule for conducting tests and making recommendations for spill pattern modifications to NMFS and the Regional Forum by October 1998. Based on these objectives, the Action Agencies shall investigate optimum conditions to accomplish the established objectives. The recommendations from those studies will be implemented as soon as possible after consultation with NMFS.

This work has been completed for existing conditions at Bonneville, The Dalles and John Day Dams and has been partially completed for Ice Harbor Dam. Very little detailed information exists for McNary, Lower Monumental, Little Goose and Lower Granite dams, particularly for the potentially high percentage spills called for in this opinion. Scale model studies will allow a timely assessment of tailrace conditions in a stepwise manner through a full range of spill and total flow levels, and varied turbine unit operations. The final patterns should be verified to the extent possible through field observations after implementation.

3.d. The Action Agencies, in coordination with NMFS and the Regional Forum, shall jointly investigate operational and structural **gas abatement measures at Grand Coulee and Chief Joseph Dams** as a part of a system-wide evaluation of gas abatement measures. The Bureau of Reclamation shall submit an interim status report to the NMFS by April 1999 stating the findings of the investigations at Grand Coulee. The Corps of Engineers shall develop and coordinate through the Regional Forum the scope and implementation schedule for a similar investigation at Chief Joseph Dam by October 1998. The Action Agencies shall coordinate with the Dissolved Gas and System Configuration Teams to identify gas abating alternatives, future actions, implementation schedules and future funding requirements for gas abatement at Grand Coulee and Chief Joseph Dams. The Action Agencies shall seek congressional authority and funding, as necessary, to implement the selected preferred alternatives.

Lower dissolved gas levels from Grand Coulee and Chief Joseph Dams would reduce background TDG levels caused by these projects, which may limit the duration of exposure of adult steelhead to high dissolved gas concentrations. Further, the passage survival of juvenile steelhead would be improved because increased spill would be allowed at downstream projects under the current dissolved gas cap.

3.e. The Action Agencies, in cooperation with the Regional Forum, shall develop **adult PIT-tag detectors** for installation in adult salmonid passage facilities at appropriate FCRPS dams as needed for calculating transport benefits, conversion rates, and smolt-to-adult survival rates for listed steelhead and other salmonids. A schedule for installing adult PIT-tag detectors at projects, which maximizes the ability to conduct research identified in this Supplemental FCRPS Biological Opinion in a timely manner, shall be developed by the Action Agencies, working through the Regional Forum, by October 1998.

The ability to interrogate PIT-tagged adult steelhead will allow more accurate assessments of critical adult passage information including conversion rates between dams, steelhead kelt survival rates, travel time, and fallback rates with minimal adult handling mortality. Additionally, it will allow estimation of smolt-to-adult survival rates for transport studies and other survival studies specified in this Supplemental FCRPS Biological Opinion. Coordination of the schedule for installing adult PIT-tag detectors at FCRPS projects is necessary to ensure that the various studies requiring adult PIT-tag detection capability can be implemented in a timely manner.

APPENDICES

BASIS FOR NMFS DETERMINATIONS
CONCERNING THE USE OF A MID-COLUMBIA FLOW OBJECTIVE
AS MITIGATION FOR
OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM

May 1998

National Marine Fisheries Service
Northwest Region
7600 Sand Point Way NE
Seattle, Washington 98115

Background

Hydrosystem development has changed both the hydrograph and the migration corridor. Pre-impoundment flows were considerably higher and water velocity at a given flow was much higher due to the smaller cross-sectional area of the river. It is not unreasonable to conclude that historical conditions under which listed steelhead evolved resulted in higher survival than present conditions (Raymond 1988).

The 1995 FCRPS Biological Opinion set flow objectives for spring/summer chinook in the lower Snake and lower Columbia Rivers based on the best information available at that time. However, system operations prescribed in that opinion required reservoirs to be as full as possible (i.e., at the flood control rule curve) by April 20, to facilitate meeting spring and summer flow objectives. This operation appears to result in lower April flows in the mid-Columbia because refilling to flood control elevation reduces discharge during that period. Actual daily average flows at Priest Rapids Dam during April, 1995 (a near-average runoff year in the mid-Columbia, 96%, and the first year of implementation of the 1995 FCRPS Biological Opinion), ranged from 64 to 228 kcfs with a monthly average of 102 kcfs; during the first three weeks flows ranged from 64 to 137 kcfs and were lower than 100 kcfs for 14 days.

Two analyses of the effects of the 1995 FCRPS Biological Opinion operation have been conducted. One shows that April flows in the mid-Columbia at Priest Rapids Dam have been considerably lower since listing of Snake River salmon (Figure 1; FPC 1997). This analysis includes both the effects of the variation in runoff each year and the 1995 FCRPS Biological Opinion operation. Another analysis is a 50-year model study which compares hydrosystem operation under the 1995 FCRPS Biological Opinion with an operation without flow augmentation for salmon. The analysis shows that flows in the mid-Columbia during the first half of April are generally higher or similar under the operation stated in the 1995 FCRPS Biological Opinion (except in some low flow years when flows are lower); flows in the second half of April were always higher under the 1995 FCRPS Biological Opinion. However, these higher flows in the second half of April appear to be the result of a modeling priority that drafts reservoirs to meet spring flow objectives at McNary without consideration for the need to refill by June 30 to assist in meeting summer flow objectives in the lower Columbia River. This is not representative of the operational priorities set out in the 1995 FCRPS Biological Opinion.

Determination

<u>Spring Flow Objective for the Mid-Columbia River</u>

Based on the best available information, NMFS believes that low river flows result in reduced survival of listed juvenile Upper Columbia River steelhead[12] and that establishing flow objectives will help increase juvenile survivals; increased juvenile survivals will potentially lead to increased adult returns in the long term. Although there have been no studies of juvenile survival over a range of flows specific to listed steelhead in the mid-Columbia reach, data pertaining to other relevant stocks in the Snake River support the designation of a mid-Columbia flow objective for steelhead of 135 kcfs at Priest Rapids. This flow objective and the supporting biological rationale are further described in Appendix A.

The NMFS defines a seasonal flow objective as a guide to the inseason process and as a mechanism for comparing various operational scenarios (e.g., one scenario might give a 70% chance of meeting flow objectives while another gives a 50% chance). The 1995 FCRPS Biological Opinion and this Supplemental FCRPS Biological Opinion give general direction to the inseason management process on the factors to take into account in making decisions about inseason operations that will result in levels of flow expected to provide the greatest survival benefits to listed fish. The biological opinions do not require seasonal average flow objectives to be met on a weekly basis, nor do they suggest that flow augmentation can be stopped or diminished once a seasonal average has been met. Rather, the requirement is to operate as described in the 1995 FCRPS Biological Opinion and in the various additional measures defined below. These operations are intended to benefit one or more listed species. For example, refilling reservoirs by the end of June, together with end-of-summer draft points, will result in a defined volume of water available for summer migrating fish. Operating to the flood control upper-rule curve on April 10 of each year will assure that a volume of water is available to augment flows for spring migrating fish. The goal of the inseason management process is then to use the water available from runoff and from these storage reservoir operations to augment flows as necessary to improve the survival of listed fish throughout the season. In the event that operations of the FCRPS are inconsistent with these measures, the Action Agencies will seek and consider offsetting measures to eliminate or minimize potential adverse effects. As appropriate, the Action Agencies will consult with NMFS through the 1995 RPA Measure 26 Framework process, or a similar process, to reflect the modification or to consider other reasonable measures for the species which the operation was intended to benefit.

The BPA performed 50-year hydroregulation modeling of the measures in the 1995 FCRPS Biological Opinion, as supplemented with this Biological Opinion. The model runs assumed a higher priority for achieving flow objectives than refilling projects by June 30 in all years (i.e., the

[12] Throughout this Supplemental FCRPS Biological Opinion, the nomenclature Upper Columbia River steelhead refers to the steelhead ESU. The nomenclature “mid-Columbia River” designates the reach of the mainstem Columbia River from below Chief Joseph Dam to the head of the McNary pool.

model assumed that all of the water would be used during spring if it was needed to meet the spring flow objectives). Based on the model runs, the Action Agencies estimate that the mid-Columbia flow objective (135 kcfs at Priest Rapids Dam during the period April 10 through June 30) would be achieved, on a seasonal basis, in 78% of the historical conditions. By period, the monthly model estimated that the flow objective for April 16 to 30 would be met or exceeded in 54% of the historical years; the comparable likelihoods were 86% during May and 80% during June.

Measures to Improve Flows in the Mid-Columbia River

The Action Agencies propose to improve flows in the mid-Columbia River through additional operational measures and through inseason management actions, on a weekly basis, that are designed to optimize fish survival.[13] The planning dates for operational measures in the mid-Columbia River are April 10 through June 30. To provide an additional volume of water during the spring outmigration and to thereby achieved improved flows, the Action Agencies will operate Libby, Hungry Horse, and Grand Coulee as follows. Hungry Horse and Grand Coulee will be operated to be within one-half foot of upper rule curve (URC) with the same confidence of refill as defined in the 1995 FCRPS Biological Opinion. Libby will be operated on minimum outflows to enhance the probability of being on the URC by April 10, except for releases to meet flood control, International Joint Commission requirements at Kootenay Lake, or for power emergencies. Under some conditions (especially at Hungry Horse), operating to be at URC on April 10 can result in spill being necessary to draft to the April 30 URC elevation or can result in increased risk of local flooding. The April 10 target elevation shall be modified as necessary to achieve a reasonable balance between the risk of local flooding and the objective of being as close as possible to the April 10 URC. Spill to reach URC by April 30 is be avoided when possible to keep the projects from exceeding water quality standards for dissolved gas.

Flood control operations will continue to include the ability to implement flood control shifts from Dworshak and Brownlee Reservoirs to Grand Coulee Reservoir in years when runoff conditions permit. This operation transfers system flood control from the Snake River to Grand Coulee, thereby increasing April flows in the lower Snake River when juvenile fish are migrating. To address the earlier migration timing of wild steelhead in the Snake River, the Action Agencies also propose to revise 1995 RPA Measure 1(g), changing the planning date for the start of flow augmentation in that reach from April 10 to April 3.

[13] Management of flow on a weekly basis is consistent with present operations in the Snake and lower Columbia Rivers.

In general, NMFS' goal for flow augmentation is to operate the FCRPS to match available water to fish movement during the spring and to refill reservoirs by June 30 of each year. The March 18, 1998, draft Supplemental FCRPS Biological Opinion proposed a hard constraint of storage reservoir refill in below-average runoff years, thereby reducing spring flows. However, commenters recommended against the required refill, suggesting that the principle of adaptive management would necessitate the flexibility to provide additional flows in the spring for steelhead. The NMFS, (and some commenters) believe the available data suggest that a strong priority should be placed on refilling storage reservoirs to provide water for summer flow augmentation. However, consistent with adaptive management, NMFS agrees that it would be inappropriate at this time to place an unconditional priority on refill, prioritizing summer flow augmentation for Snake River fall chinook over spring flow augmentation for all other listed species. The conditional priority that was included in the 1995 FCRPS Biological Opinion as guidance to the TMT (p. 102) is herein reaffirmed. However, lack of refill, if recommended by the TMT, should not result in substantial departures from the summer flows that would have occurred with refill.

The actual timing of flow augmentation and refill, and the degree to which the refill objective is met will be determined by the TMT. The TMT will give consideration to stock status, fish migration characteristics, and river conditions. The timing of operations to refill reservoirs may vary with the volume of reservoir inflow. Operations to refill Libby may result in refill on a date later than June 30 in high flow years and in years when flow augmentation is required for listed Kootenai River sturgeon. Operations to refill Hungry Horse may result in refill later than June 30 in high runoff years.[14] Grand Coulee may fill by July 4 if weekend flows do not decline below the 80% level of the previous 5-day average (the general management practice during the fish passage season). Due to an earlier runoff regime, operations to refill Dworshak may result in refill before June 30.

The TMT, in recommending the shaping of flows in the mid-Columbia, should consider the desire to improve flows at Priest Rapids during the period April 10 through June 30, the desire to refill storage projects, the timing and magnitude of the juvenile migration, water temperatures, spill and total dissolved gas levels, and adult fish passage and other requirements to improve the survival of listed fish. The TMT may consider and implement flows lower than the objective during the early part of the steelhead migration when relatively few fish are present, primarily in low-flow years. The TMT may provide flows greater than the objective on a weekly basis during key points in the migration, while acknowledging that flows may be lower later in the steelhead migration as necessary to reserve water for flow augmentation for summer migrants.

[14] The later refill of reservoirs prevents refill too early in a season with continued high inflows that could result in spill and therefore high total dissolved gas concentrations below the dams.

The planning dates April 10 through June 30 have been developed based on historic fish migration timing (Bickford 1997; FPC 1991 through 1997). The TMT may recommend implementation of actions for improved fish survival (e.g., flow augmentation, spill) earlier or later than these dates based on inseason monitoring of the fish migration.

Additional Water for Flow Augmentation

Many commenters stated that additional volumes of water should be identified to provide a higher probability of meeting the spring flow objective in the mid-Columbia River without reducing the likelihood of meeting the flow objectives for summer-migrating fish. In response, the Action Agencies will continue their efforts to obtain additional water from FCRPS, Canadian and upper Snake River reservoirs. The economic and technical feasibility of each measure will be evaluated once specific operations are identified.

Non-Treaty water (NTS) in Canada, managed by BPA, has been suggested as a source of additional water for flow augmentation for listed steelhead. Within the terms of the annual agreements described in 1995 RPA Measure 1(a), BPA has a firm summer, NTS release right only for water it stores in the spring. Notwithstanding the non-Treaty storage operation that was called for in 1995 RPA Measure 1(a), and the annual agreements with BC Hydro to implement this operation since 1995, BPA will consider declining the opportunity to store water in its share of non-Treaty storage during the springtime of low water years. However, this alternative operation may reduce summer flows compared to the levels that would occur under strict implementation of 1995 RPA Measure 1(a).

The Action Agencies will pursue additional summertime NTS releases from U.S. accounts, beyond the current arrangement, when flows are likely to be below flow objective levels, if mutually agreeable with BC Hydro, and if the economic impacts of additional releases are not adverse. However, there are substantial Canadian system considerations that generally diminish the availability of additional summertime releases.

In addition, the Action Agencies will continue to investigate and implement appropriate modifications to flood control operations. One such operation, in particular, involves new flood control criteria called Variable Discharge ("VARQ") at Libby and Hungry Horse projects. This revised operation is being considered in coordination with the Regional Forum and the State of Montana, sovereign tribes, Northwest Power Planning Council, and other regional interests. Implementation of VARQ has the potential to improve winter reservoir conditions and spring-time river conditions for resident fish (e.g., bull trout - proposed for listing under ESA; sturgeon - listed under ESA) and wildlife while providing higher discharges in the spring for listed anadromous species. The Action Agencies' investigation will include analyses of local and system flood control, economic impacts, resident fish and wildlife, and proposed and listed species including white sturgeon, bull trout, steelhead, and chinook species. A status report on the progress of these studies will be completed by summer 1998. Prior to implementation, the Action Agencies will complete the appropriate NEPA and ESA documentation and will coordinate with Canada under the requirements of the Columbia River Treaty.

One commenter recommended that the Action Agencies work toward normative hydrographs. A commenter also suggested that the Action Agencies should provide flows that taper off at the end of the summer season. Another recommended a sliding-scale flow objective. The 1995 FCRPS Biological Opinion contains measures which provide for volumes of water to be used for spring and summer flow augmentation under the auspices of the interagency TMT. As such, within these available augmentation volumes, the TMT has capability and flexibility to make water management decisions which provide both a normative-type hydrograph as well as a flow regime in which flows taper off at the end of the summer season. The TMT also has the ability to provide higher flows during specific periods within the limits of available water as defined by the 1995 FCRPS Biological Opinion.

Rationale

Studies conducted within and outside the Columbia Basin have established a that general relationship between increasing fish survival and increasing river flows appears reasonable (Cada et al. 1993 - Draft Report). The exact causal mechanisms and the importance of each are not entirely understood but include water velocity, spill at dams, water temperature, predation and timing of seawater entry (ISG 1996). Further, years with low river flows in the Snake do not correspond with years of good adult returns (Petrosky 1991, 1992 [- Draft Report]). Additional research is necessary, particularly for mid-Columbia steelhead.

<u>Evolutionary Considerations</u>

Historical flows and water velocities were much higher than those of today, facilitating rapid migration of smolts to the estuary. Hydropower development has slowed juvenile fish migrations because reservoirs now store water, lowering flows, which reduces water velocities.
Increased cross-sectional areas of reservoirs have also reduced water velocities. Survival of steelhead under conditions in which they evolved appears to have been much higher than present survivals (Raymond 1988).

<u>Travel Time and Survival Considerations</u>

Development of the hydrosystem has had the effects of reducing both water particle travel time (velocity) and the travel time of migrating juveniles (CBFWA 1991). Travel times of hatchery and wild steelhead between Wells and McNary Dams and Rock Island and McNary Dams have been analyzed by several investigators (FPC 1997; Giorgi et al. 1997; Berggren and Filardo 1993). Results show significant relationships (with varying degrees of predictive capability) between increasing flows and decreasing migrant travel time (Figures 2, 3, 4, and 5).

Travel time-flow relationships in the mid-Columbia and Snake Rivers are similar, i.e., significant relationships with similar shapes show travel time decreasing as flow increases (Figures 2, 3, and 5). In the Snake River, smolt-to-adult analyses have shown a flow of at least 85 kcfs to be a flow level that reduces the likelihood of high mortality (Petrosky 1991, 1992 [- Draft Report]). Thus, a comparison of the rate of travel of hatchery steelhead in the Snake River to the 1995 FCRPS Biological Opinion flow objectives in the Snake (85 to 100 kcfs) shows that juveniles average about 14 and 16 miles per day at 85 and 100 kcfs, respectively (Figure 6 [Snake River steelhead]; Berggren and Filardo 1993). For listed hatchery steelhead in the mid-Columbia to travel at 14 to 16 miles per day, flows of 125- 135 kcfs would be required (Figure 6; FPC data for mid-Columbia hatchery steelhead).

Further analysis of the flow/travel time relationship in the mid-Columbia indicates that groups of wild steelhead released from Rock Island Dam in April show a strong response to increasing flow (FPC 1997; Figure 7). Travel times of approximately 12 days to McNary Dam at 105 to 120 kcfs are reduced to approximately eight days (33% travel time reduction) with an increase in flows to 135 to 140 kcfs (14% to 29% increase). Fish released in the first half of May show a decrease in travel time to six days with flows up to 175 kcfs (Figure 8) and fish migrating during the last half of May show a decrease in travel time to four days with flows near 230 to 240 kcfs (Figure 9). Hatchery steelhead show similar results (Figures 10, 11, and 12).

This response of steelhead to flows during all periods of their migration has been investigated by a modeling effort by Van Holmes (1997). Holmes found that in the mid-Columbia, steelhead begin their migration with high migration rates, use the current extensively and do not show much seasonal variation in migration rate. In this analysis, reductions in travel time of migrating juvenile steelhead appear to occur with increasing flows across the full migration season.

Past recommendations have suggested 140 kcfs as a minimum flow in the mid-Columbia River between early April and mid-June (CBFWA 1991; FPC 1997). Travel time information for wild steelhead in the mid-Columbia indicates that 135 kcfs is a conservative flow objective; reductions in travel time are apparent at even higher flows (Figures 2 and 3).

Temperature Considerations

Other environmental variables in addition to flow affect the travel time of migrating juveniles. Breggren and Filardo (1993) found that temperature and flow explained about equal proportions of the variation in estimated travel time of mid-Columbia hatchery steelhead. The effect of increasing river temperatures was to decrease smolt travel time. Laboratory information suggests that water temperatures in excess of about 54° F for about 20 days may cause steelhead smolts to revert to parr (Chapman et al. 1994). Water temperatures in the mid-Columbia at Rock Island Dam were 53° F in late April in 1989, 1990 and 1993, and temperatures were 54 to 55° F in 1992

(FPC 1994). Reducing the travel time of migrating steelhead smolts by increasing flows would enable more fish to emigrate before water temperatures reach 54° F or higher, reducing residualism.

Smolt-to-Adult Survival Considerations

Smolt-to-adult survival analyses take more factors into account than do juvenile river reach survival estimates. Factors include lower Columbia riverine conditions below Bonneville Dam, estuarine conditions, extent of the Columbia River plume, ocean conditions and adult losses during migration.

Brown (1995) estimated smolt to adult survival rates (SAR) for mid-Columbia hatchery-origin summer steelhead returning to Priest Rapids Dam from 1984 to 1992. A regression of SARs against April 15 to May 15 average flows (Figure 13) indicates that SARs were less than one percent at flows below 135 kcfs and were always greater than one percent at flows above 135 kcfs. Average SARs at less than 135 kcfs were 0.74%; SARs above 135 kcfs averaged 2.1%, almost three times higher.

Raymond (1988) estimated the SARs of hatchery and wild steelhead from the mid-Columbia between 1962 and 1984. A regression of SARs against April 15 to May 31 average flows (Figure 14) indicates that flows above 120 kcfs generally resulted in higher SARs than flows below 120 kcfs; SARs as high as those above 120 kcfs did not occur below 120 kcfs.

Mullan et al. (1992) estimated SARs of Wells hatchery steelhead from 1982 to 1987. A regression of SARs against April 21 to May 31 average flows (Figure 15) indicates that flows above 140 kcfs resulted in SARs generally three times higher than flows below 140 kcfs.

REFERENCES

Berggren, T.J., and M. Filardo. 1993. An analysis of variables influencing the migration of juvenile salmonids in the Columbia River basin. North American Journal of Fisheries Management 13:48-63.

Bickford, S.A. 1997. Historical hydroacoustic information for Wells Dam 1982 to 1996 and proposal for the operation of the Wells bypass system. Public Utility District No. 1 of Douglas County, East Wenatchee, Washington.

Brown, L.G. 1995. Mid-Columbia River summer steelhead stock assessment. A summary of the Priest Rapids steelhead sampling project, 1986-1994 cycles. Washington Department of Fish and Wildlife, Wenatchee, Washington.

Cada, G.F., M. Deacon, S. Mitz, and M. Bevelhimer. 1993. Review of information pertaining to the effect of water velocity on the survival of juvenile salmon and steelhead in the Columbia River basin. Oak Ridge National Laboratory. Draft Report. U.S. Dept. of Energy, Northwest Power Planning Council, Portland, Oregon. Contract DE-AC05-84OR21400. 70 p.

Chapman, D., C. Peven, T. Hillman, A. Giorgi, and F. Utter. 1994. Status of summer steelhead in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, Idaho. 235 p. + appendices.

Columbia Basin Fish and Wildlife Authority (CBFWA). 1991. The biological and technical justification for the flow proposal of the Columbia Basin Fish and Wildlife Authority. Columbia Basin Fish and Wildlife Authority, Portland, Oregon. 55 p.

Fish Passage Center (FPC). 1991. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1992. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1993. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1994. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1995. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). 1996. Smolt monitoring program. Annual Report. Fish Passage Center, Portland, Oregon.

Fish Passage Center (FPC). May 15, 1997. Data included in a letter from Washington Department of Fish and Wildlife to the U.S. Bureau of Reclamation.

Giorgi, A.E., T. Hillman, J. Stevenson, S. Hayes, and C. Peven. 1997. Factors that influence the downstream migration rates of juvenile salmon and steelhead through the hydroelectric system in the mid-Columbia River basin. North American Journal of Fisheries Management 17:268-282.

Independent Scientific Group (ISG). 1996. Return to the river: restoration of salmonid fishes in the Columbia River ecosystem. U.S. Department of Energy, Northwest Power Planning Council, Portland, Oregon. Publication No. 96-6. 584 p.

Mullan, J.W., K.R. Williams, G. Rhodus, T.W. Hillman, J.D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. Monograph I. U.S. Fish and Wildlife Service, Leavenworth, Washington.

Petrosky, C.E. 1991. Influence of smolt migration flows on recruitment and return rates of Idaho spring chinook salmon. Idaho Department of Fish Game, Boise, Idaho. 23 p. + figures.

Petrosky, C.E. 1992. Analysis of flow and velocity effects: smolt survival and adult returns of wild spring and summer chinook. Chinook Smolt Workshop Draft Summary. Idaho Dept. Fish Game, Boise, Idaho. 8 p. +figures.

Raymond, H.L. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer chinook salmon and steelhead in the Columbia River basin. North American Journal of Fisheries Management 8:1-24.

Van Holmes, C. 1997. Juvenile Salmon Travel Time Models -- http://www.cqs.washington.edu/crisp/tt/index.html.
In: R.W. Zabel. 1994. Spatial and temporal models of migrating juvenile salmon with applications. Ph.D. Dissertation, University of Washington, Seattle, Washington.

BASIS FOR NMFS DETERMINATIONS CONCERNING THE USE OF JUVENILE FISH TRANSPORTATION AS MITIGATION FOR OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM

May 1998

National Marine Fisheries Service
Northwest Region
7600 Sand Point Way N.E.
Seattle, Washington 98115

Background

Transportation has demonstrated benefits for Snake River spring/summer chinook and steelhead and is likely to benefit Snake River fall chinook and sockeye salmon. Accordingly, NMFS decided in the 1995 Biological Opinion (1995 FCRPS Biological Opinion) on Operation of the Federal Columbia River Power System (FCRPS) that it is appropriate to continue to rely on transportation as a major means to mitigate the adverse impacts of the FCRPS projects. At the same time, however, National Marine Fisheries Service (NMFS) recognized the concerns raised about uncertainty in the application of the data to operating decisions, the absolute benefits of transportation, and its ultimate efficacy as a recovery tool. The NMFS agrees that transportation by itself is unlikely to provide sufficient adult returns for recovery of listed Snake River salmon. As a result, the 1995 FCRPS Biological Opinion recommended an improved evaluation of transport and inriver survival and adult return rates to provide better information for use in decisions on long-term alternatives. Although results from groups released after 1996 will not be available in the 1999 decision time frame laid out the 1995 FCRPS Biological Opinion, NMFS believes it is appropriate to continue to collect this information during 1998 and beyond. (Other PIT-tag studies such as the hatchery study will also provide valuable information on survival under optimal inriver conditions.)

The NMFS study plan requires measures to keep control fish inriver (or return them to the river if they happen to be collected), to estimate their survival to below Bonneville, and to provide the best possible survival conditions for inriver migrants. To accomplish this, an interim operation was adopted that involved some reduction of spring transport. That is, spring transport from McNary Dam has been eliminated (note: 1994 was the last year of spring transport from McNary; summer transport from McNary continues under this Supplemental FCRPS Biological Opinion). In addition, spring spill is provided at Little Goose and Lower Monumental Dams in years in which flows are expected to exceed 85 kcfs, and at Lower Granite Dam in years in which flows are expected to exceed 100 kcfs. The 1995 FCRPS Biological Opinion also empowered the Technical Management Team (TMT) to make adjustments to keep more fish inriver if evidence is presented that fish would benefit.

The NMFS acknowledges that there is a risk that this operation will result in fewer adult returns of chinook and steelhead in the near term than would occur with maximum collection and transport (i.e., through the elimination of spill at the collector projects). However, the 1995 FCRPS Biological Opinion initiated a process to gather and analyze information in anticipation of a long-term decision to minimize risk to chinook. The ability to make a timely decision on long-term alternatives is critical to the no-jeopardy conclusion in that opinion. Therefore, we believe that the near-term risk of lower adult returns is justified on the basis of the information to be gained on the performance of inriver migrants under the best possible conditions with the existing dams.

The effect (though not the intent) of the 1995 FCRPS Biological Opinion operation was a spreading of the risk, because it assured that a greater proportion of fish would remain to migrate inriver while also assuring implementation of the best possible survival conditions for inriver migrants. At the time, NMFS estimated that the operation (absent inseason adjustment by the TMT) would result in transport of 74% of the spring/summer chinook arriving at Lower Granite Dam during years when the average spring flow at Lower Granite Dam varied between 85 and 100 kcfs, and 56% in years when flows were higher than 100 kcfs. The actual percent hatchery and wild smolts transported, as estimated by Graves and Ross (1998 - Draft Report) are shown in Table B-1, below.

Table B-1. Estimated percent juvenile spring/summer chinook transported (Graves and Ross 1998 - Draft Report).

Year	Estimated Percent Transported		Avg. Spring Flow at Lower Granite (kcfs)
	Hatchery	Wild	
1995	58	67	94
1996	46	60	124
1997	43	55	162

Due to large volumes of surplus spill (i.e., in excess of hydraulic capacity or of the demand for power generation) in both 1996 and 1997, a change in NMFS' policy of directing spill at collector projects would not have significantly changed these proportions of fish transported. Further, attempts to reduce or eliminate spill at Lower Granite, Little Goose and Lower Monumental would also have added to dissolved gas problems experienced at other projects in both of those years.

The question that NMFS considered for interim operations in 1998 and beyond was whether listing of Snake River and Upper Columbia River steelhead, or preliminary returns from the 1995 Snake River chinook transport study, should cause a change in the current policy as defined in the 1995 FCRPS Biological Opinion and summarized above. The potential actions resulting from a change in policy would include reduction or elimination of spill at Snake River collector projects (which is now provided only if specified flow triggers are met or exceeded) and resumption of spring transport from McNary Dam.

Due to the controversial nature of the transport decision and the fact that much of the debate centers on interpretation of the best available scientific information, NMFS and the other sovereigns who participate in the Regional Forum process referred a set of questions concerning that data to the Independent Scientific Advisory Board (ISAB). The ISAB was asked to specifically consider the likelihood that collection and transport during 1998 would result in increased adult returns compared to allowing those same fish to migrate inriver.

The ISAB's response (Williams et al. 1998) noted that "[barging juvenile stream type chinook (spring/summer) and steelhead should improve survival for some populations of these two types of fish, but it is not known which populations would benefit." The report also noted a mismatch between the current mixed barge and truck transport program and the available data for barging alone and for trucking alone. In brief, they concluded (among other things) that:

- "Spreading the risk of negative outcomes among alternative routes of hydroelectric passage is advisable..." for a variety of reasons;

- "Hydroelectric system operations need to be conducted to <u>maximize</u> survival for emigrants remaining within the Federal Columbia River Power System, regardless of the transport protocol." (emphasis added); and

- "Trucks should not be used in the transportation program."

NMFS Determination

<u>Snake River</u>: For the Snake River dams, NMFS has determined that spring spill should be continued at all three collector projects, provided that flows meet or exceed the specified triggers. The NMFS has further determined that the Lower Granite trigger should be decreased from 100 kcfs to 85 kcfs to be consistent with the trigger at Little Goose and Lower Monumental Dams. All juvenile fish collected under this operation should be transported.

<u>McNary</u>: For McNary Dam, NMFS has determined that the moratorium on spring collection and transportation from McNary adopted in 1995 should be continued. The NMFS has further determined that future research is needed on transport from McNary Dam, specifically on the response of Upper Columbia River steelhead to transportation. Development and implementation of such research was considered for 1998, but was determined infeasible. Joint development and agreement on a transportation evaluation study plan among federal, state, and tribal salmon managers is needed by the end of 1998 so that agreed upon research can begin during spring 1999. By 1999, or such time as a research plan is approved through the Regional Forum process, spring transport from McNary may occur for research purposes.

<u>Transportation of Summer Migrants</u>: In general, the switch from spring to summer spill operation will occur on or about June 20. In practice, the TMT has the discretion to make the switch earlier or later based on monitoring of inriver conditions. When more favorable spring-like flow and temperatures either end before or extend after June 20, the actual date to end spill at

collector projects should be modified, continuing to spread the risk of transport versus inriver passage so long as favorable flow and temperature conditions persist.

The Corps should work with NMFS, within the Regional Forum process, to develop a comprehensive review of trucks versus barges and to make and implement recommendations on the appropriate role of each method of transport by December 1, 1998. Meanwhile, for 1998, the Action Agencies should extend barging at the three Snake River collection dams approximately two weeks so that a greater proportion of the summer migration is barged.

Rationale

<u>Snake River:</u> The NMFS' rationale for recommending continued spill at the Snake River collector projects is comprised of the following:

(1) The transport/inriver survival evaluation should continue in 1998 and beyond with operations designed to maximize the survival of spring/summer chinook and steelhead migrating inriver. Continued comparison of juvenile survival and adult return rates between fish transported and fish left to migrate inriver will provide information on the ability of transportation to avoid mortalities associated with passage through the FCRPS, and the adequacy of either inriver or transport survival to provide for recovery in the absence of drawdowns. The maintenance of flow and spill conditions that maximize project and reservoir passage survivals for the inriver fish is critical to this evaluation.

(2) A decision to drop conditions necessary for continuation of the study and initiate maximum transport should *not* be based on partial data from a single year (i.e., the preliminary returns from the 1995 study),

(3) A significant proportion of the spring/summer chinook and steelhead populations is expected to be transported under the existing policy. Leaving remaining fish to pass inriver under better flow conditions (i.e., when the flow triggers are exceeded) is a prudent risk management strategy given even a modest likelihood that fish passed in spill, rather than *either* fish bypassed or fish collected and transported, may survive and return at comparable or higher rates.

The NMFS rationale for changing the spill trigger at Lower Granite Dam from 100 kcfs to 85 kcfs is that the resulting operation will provide more consistent transport operations throughout the Snake River, and achieve approximately the same or greater proportion of fish transported as was expected under the 1995 FCRPS Biological Opinion. There is no biological basis for applying one trigger at Lower Granite and a different trigger at Little Goose and Lower Monumental dams. The trigger at Lower Granite was set higher in the 1995 FCRPS Biological Opinion simply to increase the proportion of fish transported (thereby the Action Agencies would err on the side of more fish transported). However, the installation of extended-length screens at Lower Granite and Little Goose Dams since 1995 has since increased the proportion of fish transported under all flow conditions, obviating the need for separate flow triggers.

The Fish Passage Center (FPC) recently estimated the proportion of Snake River fish that would be expected to be transported under this operation (FPC memo dated January 29, 1998). Their estimates ranged from 54% to 68% for hatchery spring/summer chinook, 62% to 75% for wild chinook, and 63% to 77% for wild and hatchery steelhead combined. By comparison, the 1995 FCRPS Biological Opinion estimated that 56% to 74% of chinook (hatchery and wild were not differentiated) would be collected and transported under that operation.

The NMFS rationale for determining that all juvenile fish collected at Snake River dams should be transported is the following:

(1) Adult return data from PIT-tagged smolts that outmigrated during 1994 and 1995 suggest that juvenile fish detected at more than one dam returned, as adults, at a lower rate than juvenile fish that were transported or were detected at only one dam. This implies that, in some circumstances, the survival of juveniles returned to the river is lower than if those fish were transported.

(2) Available PIT-tag data indicate that the highest survival benefit of transportation has been observed for fish transported from Lower Granite and Little Goose Dams.

(3) Without transport from Lower Monumental Dam, there would be no spread-the-risk for listed salmon from the Tucannon River or for fish released from Lyons Ferry Hatchery.

(4) Bypass outfall conditions are less than desirable at Lower Monumental Dam. Conditions at the outfall in below-average runoff years, such as 1998, exacerbate the problem.

(5) With spill at the three collector dams capped at flows that result in 120% TDG saturation caps, there is likely to be relatively little difference in the proportions of fish transported between a 2-dam and 3-dam operation.

(6) Prototype surface bypass structures at Lower Granite Dam have potential to significantly reduce collection for transportation at that location.

A proposal was made in comments on the draft Supplemental FCRPS Biological Opinion to limit transportation to no more than 50% of any one population to be consistent with the recommendations of the ISAB (1998). The NMFS sought and received clarification from the ISAB on this point in the process of completing this Supplemental Biological Opinion. In an April 6, 1998, letter from R. Williams (ISAB chair) to B. Brown (NMFS), the ISAB clarified that they were “not recommending any specific proportion or limit for transported fish. Rather, we were recommending that transportation not be maximized as earlier proposed by several management entities.”

McNary: The NMFS rationale for deciding *not* to resume spring transport operations at McNary at this time stems from concerns identified in the review of adult return information from fish PIT-tagged in the Snake River in 1994 and subsequently transported from McNary Dam. These data suggest that there may be a previously undetected problem with fish collected at McNary Dam in the new facility that became operational that year. The problem may not be limited to transported fish (i.e., it may affect all fish entering the bypass), but until this question can be resolved, NMFS will recommend full spill at McNary Dam (i.e., up to the dissolved gas limit).

The NMFS is also concerned with the lack of any recent information on transport from McNary Dam. In view of significant improvements in passage downstream of McNary, and the higher proportion of Snake River fish already being barged without additional transport from McNary, NMFS believes it prudent to approach any resumption of spring transport from McNary as a research experiment focused on the response of fish originating in the Columbia River above the confluence with the Snake River.

Transportation of Summer Migrants: Results of evaluations of summer migrating fall chinook juveniles from McNary Dam all showed positive relationships. While the ISAB report did not differentiate between spring and summer migrating fish, the NMFS believes that the results of these earlier evaluations, taken together with inriver survival studies which suggest a high mortality rate for summer migrants, especially under the conditions of low flow and high temperature experienced toward the end of the migration, support a continued emphasis on maximum transport of summer migrants. With regard to the question whether increased transportation of a particular stock would be consistent with the ISAB's recommendations in situations where the risk of migrating inriver might exceed the risk of transportation (e.g., summer passage of subyearling chinook through the Snake River and lower Columbia under conditions of reduced flows and elevated water temperatures), the ISAB, in its April 6, 1998, letter to B. Brown, replied that maximizing transportation under those conditions would be consistent with its recommendation.

Truck Transportation: With respect to the use of trucking, NMFS is reviewing the information that was the basis of the ISAB's recommendation. Based solely on the high proportion of transported Snake River subyearling chinook moved by trucks (an average of 92% during 1992 through 1996), NMFS shares the ISAB's concern for this species.

Looking more closely at past practices that affected listed steelhead, NMFS noted that the switch from trucks to barges during spring generally occurred as soon as the number of fish begin to increase. During 1993 through 1997, the first day of barging varied between April 11 and April 20. The NMFS did not recommend a change in this practice for 1998 because barging from the Snake River began before the final Supplemental Biological Opinion was signed.

Historically (1993 through 1997), the switch from barges back to trucks occurred between June 13 and June 17, before the bulk of the Snake River fall chinook population had reached Lower Granite Dam. At that time, collection totals at Lower Granite Dam (all species) varied from

3,000 to 8,000 fish per day. Between July 1 and August 6, daily collection totals dropped to less than 1,000 fish per day. These numbers are well below the number of fish can be loaded into trucks under the existing density criteria, so trucking has, in the past, been used as an economical alternative to barge transport.[15]

A review of the data from 1994 through 1997, specific to wild Snake River steelhead, indicates that, if the use of barges were to be extended a little more than two weeks (i.e., if barging began on April 9 and concluded on June 24), an additional two to three percent (i.e., 10,000 to 17,000 individual) wild steelhead would be barged from the lower Snake River collector projects (Lower Granite, Little Goose, and Lower Monumental Dams) instead of being trucked.

In order to more thoroughly investigate and address the concerns raised by ISAB, the Action Agencies propose to work within the Regional Forum to develop a comprehensive review of the use of trucks versus barges and to make and implement recommendations on the appropriate role of trucks and barges by December 1, 1998. Meanwhile, for 1998, the Action Agencies further propose, insofar as funding and logistics permit, to extend barging at the three Snake River collection dams approximately two weeks so that a greater portion of the summer migration is barged.

SUMMARY OF SCIENCE RELATED TO JUVENILE FISH TRANSPORTATION

Introduction

Juvenile fish transportation has been repeatedly evaluated. Since the late 1960s, numerous studies have been conducted using chinook and steelhead smolts. The vast majority of studies show that transported smolts return as adults at a higher rate than inriver control fish similarly collected and marked, but allowed to continue their migration inriver. These data have been peer-reviewed by independent scientists on several occasions. Nevertheless, controversy stemming at least in part from uncertainty over the application of these results to mitigation decisions abounds.

In addition to the transport/inriver comparison studies, various researchers have also evaluated and measured smolt performance, stress, behavior, mortality, disease transmission, and behavior. The results of all these studies have been used to help manage the juvenile fish transportation program.

[15] The Corps estimates a cost differential of 5.5 times (i.e., $17,000 per trip for barged fish compared to $3,150 per trip for trucked fish).

Pertinent findings to date include:

- Transportation helps reduce the number of juvenile salmonids killed in the existing hydropower system, and thereby increases the number of adults returning to upriver dams and hatcheries.

- The conditions experienced by groups of study fish migrating in the river are largely determined by power system operations.

- Nearly all information concerning the impact of transportation on migrating smolt physiology and performance has been collected from hatchery fish. No clear trends in swimming performance have been observed in chinook salmon -- either before or after barging.

- In early season trials, elevated levels of blood plasma cortisol (a physiological indicator of stress) in barged chinook salmon and steelhead were largely eliminated during transport. However, at the peak of the migration, plasma cortisol levels remained elevated throughout the collection and transportation process.

- Video monitoring of fish behavior in raceways (and in barges during transport) show startle responses of undetermined cause. Classic aggressive behaviors were rarely observed.

- Straying rates for transported fish are very small (one to three percent), apparently no greater than natural rates

- There are, thus far, no conclusive research results regarding transportation's ability to improve returns to the spawning grounds or to provide sufficient adult return rates to provide for the recovery of upriver runs.

- There appears to be a consistent (but small) delay during the upstream migration of some transported steelhead. This apparent difference in run-timing, if it is real, does not appear to affect the steelhead's ability to return to the hatcheries in time to spawn successfully.

- No precise data has been collected on juvenile mortality, either during or following transportation.

- Research results and routine observations do not indicate large-scale predation on smolts immediately following their release from the barges.

- Live box studies have suggested that, under certain conditions, uninfected salmonid smolts can become infected with Renibacterium salmoninarum (presumably shed from infected smolts) during inriver migration or transportation.

Discussions of these and other research findings follow.

Transportation Evaluations

The NMFS research on transportation has shown that collecting fish at upstream dams and transporting them to below Bonneville Dam can reduce juvenile salmonid mortality in the existing FCRPS relative to a control group also collected and marked at the dam, and increase the number of adults returning to upriver dams and hatcheries.

In the various studies, the survival of transported fish (determined by observations of adult returns at dams) is compared to the survival of control fish (intended to represent inriver migrants) and expressed as a transport-to-control (T/C) ratio. This ratio is based on results pooled from individual mark groups; it compares the percent of transported juvenile fish (test fish) that return as adults to the percent returning from juvenile fish that were allowed to migrate inriver, or to those from juvenile fish that were transported a short distance below the marking site and then migrated inriver (control fish).

The conditions experienced by fish migrating in the river are largely determined by power system operations, though nature still plays a role. Forced spill, when available, provides an alternative to passage through the powerhouse. Most studies have collected transport-to-control information during “below average” to “average” runoff years. Thus, there is concern that the reported transportation survival percentages may not be representative of survival during “above average” runoff years (such as 1997). Based on long-term records of runoff volume, 1986 and 1995 were “average” water years. Transport studies those years indicate positive results for transported fish (note: the 1995 study results, however, are preliminary). When available, results from the 1996 evaluation will represent migratory conditions during an “above average” water year.

There is concern within the fisheries community that control groups of fish from the NMFS’ studies may not be representative of the run-at-large, since these fish are collected and marked after having passed through a juvenile bypass system. This so called “handling” is the subject of continued debate. On the other hand, inriver migrants are expected to pass through all available passage routes (i.e., turbines, spillways, bypass systems, etc.)

Management options for not collecting and marking fish at dams are presently limited to evaluating transportation of hatchery fish. Such studies do not provide fishery managers with data on the survival of wild stocks. Ideally, sufficient numbers of wild fish could be marked far upstream of the dams so that their origin would be known and it would be possible to evaluate homing to individual hatcheries and natal streams. Adult PIT-tag detection facilities must be developed for homing studies to occur.

<u>Survival to Adult</u>

1. Chinook

a. Snake River Studies

Over the course of 24 studies at Snake River dams from 1968 through 1980, T/C ratios have ranged between 0.7 to one and 18.1 to one, with three of the studies reporting T/C ratios below parity (Ebel et al. 1973; Ebel 1980; Park 1985; Slatick et al. 1975). In ten of the tests (42%), significantly more transported fish than control fish were recovered as adults, indicating higher survival for the transported groups. In only one test were significantly more control fish recovered than transported fish. In 13 tests (54%), adult recoveries were too few to identify statistical differences between returns of transported and control fish (Matthews 1992).

Additionally, a 3-year study of Snake River spring/summer chinook salmon (and steelhead) juveniles transported by barge from Lower Granite Dam was to begin in 1986. However, low flow conditions in 1987 and 1988 precluded studies in those years. At the time, the fishery management agencies were primarily interested in evaluating transport in average- to high-water years because almost everyone believed transportation was better than inriver migration during low water years. Subsequently, only two years of the planned study were completed—1986 and 1989. Results of the 1986 research indicated a T/C ratio of 1.6 to one, with a 95% confidence interval (CI) between 1.01 and 2.47 (Matthews et al. 1992). Studies in 1989 indicated a T/C ratio of 2.4 to one, with a 95% CI between 1.4 and 4.3.

In 1995 and 1996, spring/summer chinook salmon smolts with passive integrated transponder tags (PIT-tags) were used to evaluate transportation versus inriver migration from Lower Granite Dam. However, unlike most previous studies, the inriver fish were released directly into the tailrace of the dam where they were collected and marked, instead of the usual course of transporting and releasing them below Little Goose Dam (the next dam downstream). Fin clips were used to separately record the hatchery and wild fish in both the test and control groups during tagging. Preliminary results from the 1995 evaluation show that 59 1-ocean-age and 702 2-ocean-age fish (604 hatchery and 98 wild) were recovered as returning adults at Lower Granite Dam. For hatchery fish, the preliminary T/C ratio is 2.0 to one for wild fish, the preliminary T/C ratio is 2.4 to one. Results for the 1995 study year will be complete when the 3-ocean-age fish return in spring and summer of 1998. For the 1996 study year, only jack returns are available. Results for the 1996 study year will not be complete until the summer of 1999 (G. Matthews, pers. comm.). While the majority of the juvenile salmonids presently being transported are of hatchery origin, Snake River transport evaluation studies conducted between 1968 and 1973 used predominantly wild spring/summer chinook salmon. The results of those studies show significantly more adults returning from the transported test groups than the untransported (Ebel et al. 1973; Ebel 1980; Slatick et al. 1975). The T/C ratios for adults returning to the dams during those years ranged from 1.1 to one to 18.1 to one; similar T/C ratios were documented at the hatcheries and spawning grounds (Ebel et al. 1973; Ebel 1980; Slatick et al. 1975).

Conclusion: Transportation is an effective means of helping to reduce the number of juvenile chinook killed in the existing hydropower system, and to thereby increase the number of adults returning to upriver dams and hatcheries.

b. Lower Columbia River Studies

i. Yearling chinook

A 3-year series of studies of transportation from McNary Dam on the lower Columbia River was conducted in the late 1980s. Studies in 1987 suggest there is a positive association between transport and survival of spring chinook salmon, this is based on a pooled T/C of 1.6 to one (95% CI, 1.18 to 2.25). The T/C ratios for all individual mark groups were positive; however, the lower limit of the 95% confidence intervals for three of the five groups was less than one (Achord et al. 1992). Transportation studies using spring chinook salmon at McNary Dam in 1988 resulted in a T/C ratio of 1.6 to one, with a 95% CI between 1.0 and 2.6.

ii. Subyearling Chinook.

Transportation evaluations of fall chinook subyearlings migrating during the summer have shown positive benefits. Adult returns of fall chinook salmon released from McNary Dam in 1986 as juvenile transport and control groups indicate a T/C ratio of 2.8 to one, with a 95% CI between 1.4 and 5.6 (Harmon et al. 1993). Studies at McNary Dam in 1987 also show a positive association between transportation and subyearling chinook salmon survival (T/C of 3.5 to 1; 95% CI 1.7 - 7.1) (Harmon et al. 1995). The NMFS initiated a new 3-year subyearling chinook transport evaluation from McNary Dam in 1995. Marking occurred in 1995 and 1996 using ad-clip/coded-wire tagged groups. Control groups were released to the tailrace through the bypass outfall of the new juvenile facility, whereas transported groups were trucked or barged. The third year of marking has been postponed pending the availability of funds. Study results will be based on adult recoveries in ensuing years. Generally it takes six to seven years to be certain that all tags are in from the year in which the juveniles were marked.

Conclusions: The benefits of transporting yearling chinook from McNary Dam under existing migratory conditions are unknown. Previous studies evaluated facilities and migratory conditions that are no longer representative. A new juvenile facility was completed in 1994, therefore, additional studies are desirable. Results of past studies of subyearling chinook all showed positive relationships. Results of more recent studies will not be available for some time.

2. Steelhead

a. Snake River Studies

From 1969 through 1980, 22 separate juvenile steelhead transportation studies were conducted at dams on the Snake and Columbia Rivers. Of the 22 studies, 17 were conducted at various Snake River dams and five were conducted at McNary Dam on the Columbia River. Transportation methods using both trucks and barges were tested. In all of the Snake River studies, steelhead that were transported as juveniles had significantly higher adult return rates than did those that migrated inriver. The 17 Snake River studies showed T/C ratios ranging from 1.3 to one to 17.5 to one (Ebel et al. 1973; Slatick et al. 1975; Ebel 1980; Park 1985; Matthews 1992).

Studies conducted in 1986 and 1989 also demonstrated positive transport benefits. Steelhead transported by barge from Lower Granite Dam in 1986 showed a T/C ratio of 2.0 to one, with a 95% CI between 1.4 and 2.7 (Matthews et al. 1992). Results from a similar study conducted in 1989 showed a T/C ratio of 2.1 to one, with a 95% CI between 1.3 and 3.5 (Harmon et al. 1995). These results confirm the earlier work with steelhead and strongly indicate that more adult fish return from juveniles transported to below Bonneville Dam than do from juveniles allowed to migrate through the hydropower system.

Steelhead Adult Return Rates. During studies conducted at Lower Granite Dam from 1975 through 1980, adult return rates of transported juvenile steelhead were consistently between 2.5% and 4.7% for the composite hatchery/wild population (Park 1985). During that period, Raymond (1988) estimated wild fish annually made up roughly 30% to 70% of the smolt population. Similarly, from 1984 through 1988, adult return rates of transported steelhead were consistently between 2.6% and 3.2% for the composite population. Since 1986, all hatchery steelhead juveniles have been identifiable by an adipose fin clip—allowing adult return rates and T/C ratios to be independently estimated for hatchery and wild fish. Adult return rates of wild steelhead juveniles transported in 1986, 1987, and 1989 were 4.5%, 2.7%, and 0.8%, respectively (G. Matthews, NMFS, personal communication).

In 1994, the Independent Peer Review Team (IPRT) completed a review of the data available on the benefits of transporting juvenile fish (Mundy et al. 1994). The IPRT findings and conclusions indicated that “the kinds of Snake River salmon for which transportation is likely to improve relative survival to the point of transportation are the steelhead, and to a lesser degree, the yearling-migrant stream-type chinook salmon designated as "spring/summer chinook" salmon by NMFS.”

Conclusion: Transportation is an effective means of helping to reduce the number of juvenile steelhead killed in the existing hydropower system, and to thereby increase the number of adults returning to upriver dams and hatcheries.

b. Lower Columbia River Studies

In all but one of five studies conducted at McNary Dam between 1978 through 1980 (three truck tests and two barge tests), significantly more adults were recovered from groups that were transported than from groups released as inriver control fish. In one study, a trucked group returned at only a slightly higher rate than the paired inriver control (the difference was not significant). T/C ratios ranged from 1.3 to one to 3.0 to one (Park et al. 1984). The two barging studies (1979 and 1980) demonstrated statistically significant differences between transported and control groups in both years (Park 1985). The 95% confidence intervals were not developed for data analyses of the studies conducted prior to 1986.

Conclusions: The benefits of transporting steelhead from McNary under existing migratory conditions are unknown. Additional studies are needed but technological problems (i.e., adult PIT-tag detection capability in fishways at several dams) must be overcome. Past studies showed positive benefits. However, a new juvenile facility, with much improved bypass outfall conditions, was completed in 1994. Preliminary results of PIT-tag data analysis suggest that fish transported from McNary in 1994 returned at a lower rate than fish transported from other dams.

3. Sockeye

The only data available on sockeye salmon T/C ratios are results from studies conducted on juveniles transported by truck and barge from Priest Rapids Dam between 1984 and 1988 (Carlson and Matthews 1992; Carlson and Matthews 1991). Final statistical analyses of transport benefits of these studies have not been reported and it is not known when the final report will be completed. However, the reported preliminary T/C ratios vary widely, and range from 0.55 to one to 4.23 to one.

Conclusion: The benefits of transporting sockeye from Snake River dams or from McNary Dam under present conditions are unknown.

Transportation by Truck

In the lower Snake River, juvenile fish are transported by truck for approximately two weeks early in the season, and from about mid-June to the end of the transport season at the end of October. Transport by barging occurs in the interim. At. McNary Dam, transportation (initially by trucking) begins when subyearling chinook predominate the daily collection. This usually occurs around the second week of June. Late season trucking fro McNary begins about the third week of July and continues until sometime in December when concerns related to adverse weather conditions preclude collection and transportation.

In the Snake River from 1995 through 1997, 3.0%, 1.9%, and 2.0% of the total number of yearling chinook transported were trucked, in those respective years. Similarly, 3.1%, 3.9%, and 6.8% of the total number of wild steelhead transported was by truck. In contrast, 97.4%, 94.0%, and 91.8% of the total number of subyearling chinook transported were trucked. This is because most subyearling chinook emigrate in the summer after barging is terminated in the lower Snake.

In the lower Columbia River from 1995 through 1997, 4.8%, 71.3%, and 98.5% of the total number of yearling chinook transported from McNary were trucked, in those respective years. Similarly, 2.5%, 81.6% and 91.8% of the total number of wild steelhead transported was by truck. In contrast, 6.3%, 39.4%, and 64.9% of the total number of subyearling chinook transported were trucked. Although these percentages appear alarming, one must consider that there has been no transportation of spring migrants from McNary, except for those that are collected coincident with subyearling chinook. All spring migrants passing through the juvenile bypass system are returned to the river after PIT-tag detection.

Recommendation of the ISAB: In its February 27, 1998 response to several questions posed by the Implementation Team, the ISAB concluded that "Trucks should not be used in the transportation program due to a lack of information needed to advise management, due to the absence of current research programs to collect such information, and because historical indications on truck transport are negative."

In our view, the statement that "historical indications on truck transport are negative" based on evidence from two studies not involving lower Snake River stocks is troubling. The previous section of this document describing straying and homing support the position that straying of transported Snake River stocks is not a problem. Admittedly, there are not a lot of data but were are not aware of anything pointing to a disadvantage from trucking. Fish transported by truck in the early season are released from the shoreline daylight, rather than mid-river, as occurs in the late trucking season. Therefore, potential predation is a concern. There are several release points on both the Oregon and Washington sides of the Columbia River and fish truck personnel are familiar with river conditions at various flow levels.

There are few data which directly compare the benefits of truck versus barge transport.. The data that are available are from six studies conducted from 1978 to 1983 at Lower Granite and McNary Dams. Of these six studies, one found statistical significance that barging was better than trucking. In general, trucked-fish groups demonstrated very positive benefits compared to the control group.

The results of studies comparing the Corps of Engineers' 1985 Comprehensive Report on Juvenile Salmonid Transportation (Park 1985) reported the following transport:control benefit ratios for trucked versus barged groups of smolts:

Table B-2. Transport:control benefit ratios for chinook and steelhead transported by truck versus barge (Park 1985).					
Year	**Location**	**Species**	**Truck**	**Barge**	**Sig. ?**
1978	LGR	subyearling chinook	5.8	8.9	yes
1978	LGR	steelhead	4.4	5.2	no
1979	MCN	steelhead	2.1	3.0	no
1980	LGR	subyearling chinook	*	*	insufficient returns
1980	MCN	steelhead	1.3	1.4	no

In his Summary and Conclusions section, Park thought that additional research was warranted before drawing final conclusions on the merits of truck versus barge transportation.

The 1983 study evaluated truck versus barge transport for fall chinook from McNary Dam. Combined (early, middle, late phase) results indicated transport benefits of 3.19 for the trucked fish groups, and 2.90 for barged groups. Trucked fish from the early and middle phase groups actually had a higher survival than the barged groups. Pooled results, however, showed no statistical difference (Matthews et al. 1987).

Analysis of 1994 and 1995 PIT-Tag Data

The NMFS has conducted research studies for more than 25 years to evaluate whether transportation of juvenile fish from upper Snake River dams increased adult fish returns compared to returns from juvenile fish that migrated through the hydropower system. The general methodology for all of the studies was to collect fish at a dam and mark two groups - one for transportation and one for migration through the hydropower system. Fish for transportation were placed into either trucks or barges, transported below Bonneville Dam, and released. Fish marked to evaluate migration through the hydropower system were generally trucked and released a few kilometers upstream of the dam where they were marked, or trucked downstream below Little Goose Dam and released. In the late 1970s, some control fish were released directly into the tailrace of lower Granite Dam, but an unknown number were likely subsequently collected and transported from Little Goose Dam. Adult returns from studies conducted between 1968 and 1989 all indicated a higher adult return rate from fish transported than from those that migrated through the hydropower system. Nonetheless, the overall adult return rate of salmon was, in nearly all cases, much lower than historic rates of return prior to completion of the Snake River dams and John Day Dam on the Columbia River. In spite of the higher return rates of transported fish, many in the fisheries community suggested that transportation was ineffective because absolute return rates were much below historic levels. This prompted some recent reviews of the transportation research. The reviews generally concluded that fish released as controls in the earlier studies were not “true” controls because they were transported to release sites.

To address this issue, NMFS began new studies in 1995 to evaluate transportation of spring/summer chinook salmon from Lower Granite Dam. All fish in the new studies were individually marked with PIT tags. Daily, a group of fish were loaded into barges for transportation. Another group was released directly back to the tailrace of Lower Granite Dam. The development of slide-gate systems at collection facilities downstream of Lower Granite Dam so that river migrants were not transported. Any fish designated for the river migrant groups that were inadvertently transported were identifiable and removed from the study data base. To date, 1- and 2-ocean adult fish have returned from the 1995 study. In 1998, 3-ocean fish will return. We estimate that 75% to 80% of the hatchery fish and 20% to 30% of the wild fish have returned thus far. As previously reported (memorandum dated August 1, 1997, from M. Schiewe to W. Stelle), preliminary results indicate that the adult return rate of PIT-tagged, transported spring/summer chinook salmon was approximately twice as high as the PIT-tagged fish released into the tailrace of Lower Granite Dam that migrated through the hydropower system.

In late 1997, NMFS and Idaho Fish and Game biologists began a detailed examination of wild and hatchery steelhead and spring/summer chinook salmon returns from fish that were PIT-tagged in 1993 (PIT-tagged as parr, but migrated in 1994), 1994, or 1995 and released at sites *upstream* of Lower Granite Dam. PIT-tagged fish that migrated in 1994 and 1995 and were collected in the bypass systems at Lower Granite, Little Goose, Lower Monumental, and/or McNary Dams and were detected by PIT-tag electronic detection systems were sorted into different categories depending on their detection histories at the four dams. At each dam, fish were either detected and transported, detected and bypassed back to the river, or were not detected (presumably passed the dams via spill or turbines). A small number of fish were detected but their fate was unknown. The two categories given the most attention recently are: (1) fish transported at Lower Granite and Little Goose Dams and (2) fish that passed through the four dams undetected. The number of transported fish was known, but the number of fish that passed through the system but were not detected required an estimate.

Conditions varied between the two migration years. In 1994 there was no spill and moderate flows until May 10th and then high flows with high spill. In 1995 there were moderate flows throughout the migration period and spill was provided at all dams downstream of Lower Granite Dam throughout the migration period. Adult returns from the 1994 migration and 1995 juvenile steelhead migration are complete, while 1995 spring/summer chinook salmon migration adult returns are incomplete.

Unlike the 1995 NMFS transport study at Lower Granite Dam, PIT-tagged fish released above Lower Granite Dam were tagged for many reasons, at many locations, and may not represent the population of untagged fish. Further, fish from these groups may not have arrived at Lower

Granite Dam or migrated through the hydropower system similar to the general population. With relatively small numbers of juvenile fish and low numbers of adult returns in the different detection history categories, they may only represent small segments of general population. Additionally, numbers of fish in different detection history categories were not set to accurately ensure statistical power to detect true differences in adult returns.

We have not yet conducted statistical analyses comparing return rates between different detection history categories. Such analyses require variance estimates that are not yet developed. Variance estimation is complicated because variability is introduced at several steps in the process of estimating return rates, and the variance components interact in mathematically complex ways. Statistical inference for comparisons involving data from the studies of PIT-tagged fish released above Lower Granite Dam will be made when appropriate variance estimates are determined. In many cases, insufficient statistical power will exist to detect true differences between groups because of relatively small adult return numbers and/or imprecise return rate estimates. However, based on preliminary inspection of these data, the following *patterns* were observed:

1. Fish detected at multiple dams returned at a lower rate than fish transported or detected at only one dam.

2. In most cases, fish transported from McNary Dam in 1994 returned at a lower rate than fish transported from other dams.

3. From the 1994 juvenile migration, wild and hatchery steelhead and wild spring/summer chinook salmon transported from Lower Granite and Little Goose Dams combined returned at higher rates than those that passed through the hydropower system undetected under existing conditions.. However, the reverse occurred for hatchery spring/summer chinook salmon in 1994 and hatchery steelhead in 1995 (no adult returns for wild steelhead for either group in 1995).

4. In both 1994 and 1995, approximately 5% to 15% of the estimated population of PIT-tagged fish that arrived at Lower Granite Dam migrated undetected to below McNary Dam.

The above patterns are potentially important considerations in determining future operations and configuration of the hydropower system. Accordingly, NMFS intends to aggressively pursue collection and analysis of these and future data to provide a biologically and statistically rigorous rationale for future management decisions (Memo from M. Schiewe to W. Stelle, dated March 23, 1998). Of interest will be cooperative analyses of complete 1995 PIT-tag data to address concern by some that the survival-to-adult return of PIT-tagged smolts passing through the hydropower system undetected is no different than the survival of transported juveniles.

Behavior

Impaired swimming performance can reasonably be expected to reduce juvenile survival following their release. Chinook salmon swimming performance has been evaluated before and after barging and no clear trends have been observed (Schreck and Congleton 1994).

Fish behavior has been examined (using underwater video) in raceways and in barges during transport. Most of the observed interactions were startle responses of undetermined cause. Classic aggressive behaviors were rarely observed. The behavior of yearling chinook immediately after their release was also monitored using radiotelemetry. The information provides an estimate of the downstream migration speed for each radio-tagged fish, gives the minimum number of tagged fish successfully migrating through the prescribed release area, and allows estimates of their migration time and rate of survival from the smolts' release below Bonneville Dam to their arrival at the estuary. At release, most of the radio-tagged fish released from barges moved downstream at a rate of one to two miles per hour. This rate of movement is comparable to that observed in previous study years. The majority of the tagged fish reached the estuary in 36 to 72 hours after release (Schreck and Congleton 1994). Radio-tagging studies of migration speed have found that run-of-river yearling hatchery chinook migrate faster than do barged hatchery chinook released at the same time and under the same flow conditions. Run-of-river fish also appear to travel in tighter groups than do barged fish. The authors speculate that the observed difference in travel time may be the result of some difference in fish condition. However, the barged chinook groups were known to be Snake River stocks, whereas, the run-of-river chinook collected and tagged at Bonneville were not. The authors also speculate that an insufficient degree of smoltification, or osmoregulatory or other disturbances associated with transportation, may potentially delay ocean entry (Schreck et al. 1997).

Conclusions: Nearly all information concerning the impact of transportation on migrating smolt physiology and performance has been collected from hatchery fish. No clear trends in swimming performance have been observed in chinook salmon—either before or after barging.
Video monitoring of fish behavior in raceways (and in barges during transport) show startle responses of undetermined cause. Classic aggressive behaviors were rarely observed.
Research results and routine observations do not indicate large-scale predation on smolts immediately following their release from the barges.

Straying/Homing Impairment

According to Quinn, "straying is the migration of mature individuals to spawn in a stream other than the one where they originated. From the standpoint of orientation, a salmon strays if it ascends a non-natal river and does not subsequently make its way to its natal river. If a fish enters a hatchery, it is seldom given the chance to retreat, so there is some question as to whether 'strays' entering hatcheries would have eventually left." Further, "estimates of straying vary greatly between hatcheries and rivers, so general statements on straying proportions have minimal biological significance" (Quinn 1993).

<u>Natural Straying Rates</u>

A study by Shapovalov and Taft at Scott and Waddell Creeks (California) found that steelhead strayed between the creeks at rates of two and three percent, respectively. Another study by McIsaac on the homing of wild, wild/hatchery (reared 10 weeks in a hatchery), and hatchery fall chinook in the Lewis River (Washington) found that the wild chinook strayed at a rate of 3.2%. Wild salmon have also been observed to stray into hatcheries. Nicholas and Van Dyke estimated that 64.7% of the wild coho salmon returning to the Yaquina River watershed (Oregon) in 1981 entered the Oregon Aqua-Foods hatchery (reported by Quinn, 1993).

Straying Rates of Transported Salmon

There is no direct evidence to show that wild and hatchery salmon, transported from Snake River dams as juveniles, wander into rivers at higher rates than they would naturally. Reported rates of straying among transported fish are very small (one to three percent). Marked steelhead from transport study groups (control and transported) have been reported in the Deschutes River (Oregon). Specifically, during the trucked-fish transport studies conducted during 1970 through 1973 at Little Goose Dam, the T/C ratios were the same for adult steelhead recovered from the Deschutes River and for those captured at Little Goose. This indicate that the trucked fish were not straying into the Deschutes at any rate higher than did fish that migrated in the river as smolts. Further, in studies conducted between 1975 and 1980, 11 spring/summer chinook (0.9% of the run), and 16 steelhead adults (0.2% of the run) were identified as "strays." All were transported from Lower Granite or Little Goose Dams. Among the steelhead, 11 of the 16 were released in 1976 (before barge transport began). All of the chinook were observed in the Deschutes River (Oregon), whereas, the steelhead were observed at Wells Hatchery (9), the Deschutes River (3), Big Creek Hatchery (1), Chelan Hatchery (1), and the Yakima Hatchery (1). Ebel concluded, and Park agreed, that straying has a minimal impact on the adults' ability to return to expected spawning areas (Corps 1985).

In analyzing steelhead returns, Park determined that transported fish exhibited a consistent but small delay during their upstream migration. The number of transported fish returning in the spring of each year was higher than that number among the controls (see below) implying a delay for the transported fish. About 10% of the transported fish delayed during migration. Further analysis indicated that transporting steelhead from the Clearwater River causes a minor delay in their upstream passage (Corps 1985). Matthews (1992) postulated that the delay Park noted was more likely due to a slightly later river entry for adults returning from groups that were transported as juveniles. This was not observed in the A-run steelhead because most were above the dams when their migrations ceased the previous fall; therefore, they would not have been observed at the dams during the spring migration. Because B-run steelhead migrate later than the A-run, the late segment of that population would over-winter in the reservoirs below the dams and could thus be observed the following spring when they continue their migration. This may have been occurring in the A-run as well, but it simply was not observed. In any event, the slight difference in run timing, if it is real, does not appear to affect the steelhead's ability to return to the hatcheries in time to spawn successfully.

The Independent Peer Review Team (IPRT) findings indicate that, due to the experimental design of the studies, Snake River transportation research results to date are not conclusive regarding the ability of transportation to improve returns to the spawning grounds (Mundy et al. 1994). Limited evidence exists, however, based on adult returns at hatcheries. For transportation studies conducted from Lower Granite on steelhead in 1986 and 1989, the T/C ratios for adult returns recovered at hatcheries above Lower Granite Dam were not different in either year than the T/C ratios measured on adult fish at the dam (Matthews et al. 1992, Harmon et al. 1993).

Mid-Columbia Studies

The transportation of spring chinook and sockeye salmon juveniles from Wanapum and Priest Rapids Dams was researched from 1984 through 1988. These studies indicate that jaw-tagged sockeye adults (that were transported as smolts) took longer to reach Priest Rapids Dam than did the control groups in two of five years; chinook adults took longer in one of three years. Jaw-tagged sockeye and chinook adults from transported groups fell back below Bonneville Dam more often than did control group adults, and sockeye transported solely by truck fell back more often than did sockeye transported by barge. These results suggest that transportation impairs homing (expressed as migration delay) in adult sockeye between Bonneville and Priest Rapids Dams. The studies did not, however, indicate that sockeye or chinook homing was impaired between Priest Rapids Dam and the spawning areas. Coded-wire tag (CWT) recoveries from sockeye suggest straying occurred in four truck-transported and four control fish from the 1985 tests. Other CWT recoveries include two trucked- and one trucked-and-barged sockeye from the 1987 tests. The authors did not view those eleven strays as excessive—though straying likely exceeded the number estimated from CWT records. For example, two jaw-tagged and truck-transported sockeye adults from the 1985 study were found in the Lewis River. For chinook salmon that were transported by truck, four strayed in 1984 and eight strayed in 1985. However, all of the 12 had passed hatchery weirs and therefore could not return downstream. According to the authors, the fact that all but one of the 12 were from transported groups may indicate more wandering by chinook salmon trucked as juveniles. The authors cautioned that homing results observed in transported and control sockeye and chinook salmon have relevance primarily for the conditions that were created for their study, and may or may not have relevance elsewhere for trucked or trucked-and-barged sockeye, or to other species or fish barged from collector dams (Chapman et al. 1997).

Recent Straying Concerns

Last fall, concerns were raised over a reported increase in out-of-basin hatchery steelhead reported in the Deschutes River (Oregon) late in the season. Deschutes Basin hatchery steelhead receive distinctive marks so non-native steelhead are identifiable at hatcheries and weirs. Some suggest that, based on the timing of these observations, the majority of these fish remain to spawn in the Deschutes. Since spawning between native and out-of-basin stocks can impact genetic viability, there is valid cause for alarm. Observations of non-Deschutes hatchery steelhead at Sherars' Falls and at upstream hatcheries have increased simultaneously with increased numbers of steelhead transported from the Snake River. Olsen et al. (1991 - Draft Report) attempted to correlate an increase in adult hatchery steelhead straying into the Deschutes River with an increase in the number of steelhead juveniles being transported from the dams. There is no direct evidence, however, that this is occurring, nor is there any to show that this behavior may be related to juvenile fish transportation.

Research that was conducted from 1992 to 1994 comparing the survival of steelhead transported to Tongue Point, Oregon with that of steelhead transported to the traditional release site below Bonneville Dam provides some information regarding the straying of transported fish into the Deschutes River (Oregon). Overall returns through 1996 (preliminary results), show that 573 steelhead returned to Lower Granite Dam, nine were observed in the Deschutes. This is therefore, a straying rate of 1.6%, well within expected natural straying rates. There were no marked, inriver transport control groups for the aforementioned studies. Information from the 1986 and 1989 transportation evaluations at Lower Granite Dam showed that one out of 500 returning adult steelhead (0.2%) was observed in the Deschutes River. Pooling all the available information from the 1986, 1989, and 1992 through 1994 studies shows that ten out of 1073 (0.9%) transported steelhead that returned as adults strayed into the Deschutes River (G. Matthews, NMFS, personal communication, and Marsh et al. 1997).

Conclusions: Reported straying rates for transported fish are very small (one to three percent), apparently no greater than natural rates. There appears to be a consistent (but small) delay during the upstream migration of some transported steelhead. This apparent difference in run-timing, if it is real, does not appear to affect the steelhead's ability to return to the hatcheries in time to spawn successfully.

There are, thus far, no conclusive research results regarding transportation's ability to improve returns to the spawning grounds or to provide sufficient adult return rates to provide for the recovery of upriver runs.

Mortality

There are a number of ways fish can die during the collection, holding/loading, transport, and release procedures. Some of these losses can be directly observed in various parts of the juvenile collection system (i.e., gatewells, wet separators, raceway screens, barge compartments, etc.). Other sources of mortality cannot be observed directly (e.g., impingement on screens and potential predation in raceways and during transport). Mortality following release, which may be related to the transportation experience, is not observable but may occur, for example, through increased susceptibility to predation or disease. Overall collection facility mortality has been observed to range from 0.1% to 8.9%, depending on the individual collection facility, the species, and its life stage (Corps 1997).

There are no precise data on juvenile mortality during transportation. Data from radio-tagged chinook released below Bonneville provide some information on immediate survival following release from barges. The Corps estimates that average seasonal direct mortality (observable mortality before and during transport and at release) for collection and transportation combined is less than two percent (Corps 1993). The PATH group also assumes a 0.98 transportation survival (Marmorek and Peters 1998 -- Draft Report). Stress, injury, and disease transmission are potential causes of transport-related mortality. Larger salmonids may prey upon injured, moribund, or smaller salmonids during transportation. However, observations (using video cameras) have rarely shown aggressive behavior or dead fish on the bottom of barge compartments during release. Collection facilities and operational procedures that may contribute to mortality continue to be researched.

Studies conducted from 1992 through 1996 showed no evidence of large-scale predation on smolts immediately following their release from the barges (Schreck et al. 1993a,b [- Draft Report], 1994 [Draft Report], 1996, 1997; Schreck et al. 1995 - Draft Report). Using fixed and mobile radio tracking methods, the studies have evaluated the behavior, migration speed, and the routes taken by radio-tagged Snake River yearling chinook during and after their release from transportation barges. The studies also afford a minimum estimate of survival to the lower Columbia estuary. More recent efforts have compared the behavior of barged chinook with that of run-of-river chinook collected at Bonneville Dam. In 1996, 79% to 92% of the radio-tagged, barged yearling chinook, and 77% to 97% of the run-of-river chinook yearlings successfully reached the lower Columbia River estuary. In the 1997 studies, 74% to 97% of the radio-tagged chinook survived to near the estuary (Schreck et al. 1997). The release date made no difference in the proportion of barged yearling chinook reaching the estuary ($P = 0.60$, Chi-square test), nor was there any statistically significant difference between the barged and run-of-river yearling chinook groups ($P = 0.34$, Chi-square test, pooled release dates). In the 1996 tests, fish condition (as reflected by level of descaling) did not appear to affect the survival of radio-tagged chinook. There was no difference between individuals with greater than 10% descaling and those with less than 10% descaling in either the proportion of fish reaching the estuary or in the rate of mortality within the estuary (Schreck et al. 1997).

Preliminary data (2-ocean returns) regarding the survival of yearling chinook classified as "descaled" during marking at Lower Granite Dam are available in the NMFS 1995 transport versus inriver survival study. The reported 24-hour delayed mortality (24-h DM) of the study fish was 1.6%. At the time of tagging, four percent of the juvenile chinook were recorded as being descaled. Twenty percent of the observed 1.6% 24-h DM were listed as "descaled" at tagging. Of 703 2-ocean adults returning in 1997, five percent were listed as descaled at the time of tagging. These data suggest that descaling may affect short-term survival, but may not be a factor in overall survival to adult return (personal communication, G. Matthews, NMFS).

Mortality of intentionally descaled chinook salmon and steelhead held at the Lower Granite juvenile facility did not differ significantly from mortality observed in the control groups. Of the fish that died, in both the descaled and the control groups, 75% of the chinook and 44% of the steelhead developed fungal infections prior to death. These fungal infections normally appeared on the fins rather than on the descaled areas or elsewhere on the body (Congleton et al. 1997a - Draft Report).

Conclusion: There are no precise data on juvenile mortality during transportation. There is no evidence of large-scale predation on smolts immediately following their release from the barges. Radio-tagged yearling chinook survived from release below Bonneville Dam to the estuary whether they were transported or not. Level of descaling did not appear to affect the survival of radio-tagged chinook reaching the estuary or in their survival within the estuary.

Stress

Nearly all of the information concerning the impacts of the transportation process on the physiology and performance of migrating smolts has been derived from experiments with hatchery fish (Schreck et al. 1997).

In the early 1980s, researchers began evaluating facilities used for the collection, bypass, and transport of outmigrating chinook salmon. The response of juvenile salmon has been assessed by measuring various physiological, performance, and behavioral traits. Studies show that collection facilities and procedures increase stress among juvenile salmonids. Much of what has been learned from this work has been directly applied to management of the juvenile fish transportation program (i.e, addition of pre-anesthesia systems, open-channel flumes, shaded raceways, enlarged barge release exits, etc.).

<u>Recovery From Stress</u>

Elevated plasma cortisol levels associated with stress induced by handling and marking procedures have been found to decrease significantly (to pre-mark levels) during truck transportation (Matthews et al. 1987). The results of an 1993 study indicate that, though stress indicators in juvenile salmonids are initially elevated (plasma cortisol, white blood cell levels, composition of white blood cells, diminished avoidance behavior), they decrease as the fish are barged downriver (Schreck and Congleton 1993). Studies in 1994, however, showed that the ability of yearling chinook salmon sampled from a barge at Lower Granite Dam to survive a saltwater challenge was reduced on each of three successive test dates over the course of the juvenile migration (Schreck and Congleton 1994). More recent studies (early season trials) indicate that elevated blood plasma cortisol levels (a physiological indicator of stress) in barged chinook salmon and steelhead largely return to normal during the trip downriver. However, at the peak of the migration, plasma cortisol levels in yearling chinook salmon remain elevated throughout the collection and transportation process (Schreck et al. 1995 - Draft Report). Results from late season trials have been mixed.

Differences in Stress Response of Hatchery and Wild Chinook

Plasma cortisol concentrations taken from wild and hatchery chinook salmon in barges at Lower Granite Dam were consistently and significantly higher in the wild fish throughout the migration. The highest cortisol concentrations in both groups occurred during peak movement of juvenile chinook salmon into the collection facility (Schreck and Congleton 1994). These data suggest that recovery from collection and loading stressors is related to loading density. Mixing species together during collection and transportation may also be a factor.

Steelhead Response to Stress

Studies in 1994 and 1995 showed that collection and loading were also stressful to migrating juvenile steelhead. Steelhead smolt recovery during transportation appeared to vary widely over the course of the migration season—ranging from full recovery to pre-collection level, significantly declined but above pre-collection level, or to below pre-collection levels. It is of interest to note that in the 1994 studies, stress indices did not decline to pre-collection levels during barge transportation to below Bonneville Dam or even to Tongue Point (an additional 20 hours of potential recovery time) (Schreck et al. 1995 - Draft Report).

In 1997, a laboratory experiment was conducted to determine how well steelhead tolerate a stressful event: the water level was lowered for 15 minutes at various intervals after intentionally descaling 20% of the steelhead's body surface on the dorsal side. The fish were sampled 16 hours after the stress event. Both descaling and exposure to low water level resulted in significant increases in enzyme levels. However, no statistically significant interactions between descaling treatment and stress exposure were found, thus suggesting that the responses to the stressor were similar for descaled and control fish at all times after descaling (Congleton et al. 1997a - Draft Report).

Mixed Species Effects on Juvenile Chinook

Laboratory studies intended to simulate transportation practices were conducted in 1995 and 1996. They indicate that the presence of rainbow trout (surrogate steelhead) affected the behavior and physiology of juvenile hatchery chinook (Willamette River stock). Behavioral data indicate that the rainbow trout were very aggressive, while the chinook were passive. In confinement, the schooling behavior of the chinook did not appear to be compatible with the territorial behavior of the rainbow trout. Physiological studies found that the chinook had higher levels of plasma cortisol after rainbow trout were loaded in than did chinook in control tanks (no loading) or in tanks loaded with additional chinook. A second experiment found that plasma cortisol levels in chinook that received inflow containing rainbow trout odor were initially similar to control group levels. However, plasma cortisol levels increased two hours after the odor was introduced (Kelsey 1997; Schreck et al. 1995 - Draft Report). These data support the need for improving fish size separation to reduce species interactions.

Size separation efficiency is poor for smaller-sized salmon (yearling chinook, sockeye, coho) collected at the new juvenile facility at McNary Dam. This is due, in part, to the fact that there has been no need for size separation because all spring migrants have been returned to the river at McNary since 1995. In 1994, the first year the new juvenile facility was in operation, only 27% of the sockeye salmon collected entered the small fish distribution route (a-side). The remaining sockeye (73%) were routed to raceways containing larger salmonids (primarily steelhead) for transport.

Concern for Mixed Species Effects on Sockeye at McNary

Some biologists are concerned about the impacts that the larger hatchery steelhead may have on the 80 to 90 mm long sockeye during transport from McNary Dam. We were unable to determine whether species-specific information on physiological indicators of stress exist for this location. However, some level of assurance may be based on preliminary, results of the 1995 transport versus inriver study at Lower Granite Dam. Presently, juvenile fish can not be separated by size at Lower Granite; therefore, small and large fish are transported together. In the 1995 study protocol, marked yearling chinook were returned to raceways containing steelhead before transport. The proportions of marked chinook from the 1995 study and unmarked steelhead transported in the same compartment were comparable to the species composition proportions in the other barge compartments. As previously discussed, preliminary study results of the 1995 study show that approximately twice as many adults returned from the transported groups compared to adult returns from groups allowed to migrate inriver. This data suggest that there was no long-term negative effect of mixed species transportation on the survival of yearling chinook.

Conclusion: Elevated levels of blood plasma cortisol (a physiological indicator of stress) in barged chinook salmon and steelhead are largely eliminated during transport. However, at the peak of the migration, plasma cortisol levels remain elevated throughout the collection and transportation process. Data suggest that recovery from collection and loading stressors is related to loading density. Mixing species together during collection and transportation may also be a factor.

Disease

The incidence of bacterial kidney disease (BKD) and the potential for transmitting it between wild and hatchery stocks of spring/summer chinook salmon collected for transport are being investigated by the U.S. Geological Survey, Biological Resource Division (formerly the National Biological Survey). The purpose of this research is to determine if BKD contributes to poor survival of spring/summer chinook salmon smolts (Elliott and Pascho 1993, 1994a,b). Laboratory cohabitation and waterborne experiments indicate that Renibacterium salmoninarum, the causative agent of BKD, can be transmitted to healthy chinook salmon smolts during a 48-hour exposure to infected chinook salmon. Results of the 1992 studies indicate a high concentration level of R. salmoninarum ($1x10^5$ cells per milliliter) may be required to infect more than 50% of the exposed fish within a 48-hour period (Elliott and Pascho 1994a).

Blood plasma samples from yearling chinook salmon in gatewells and barges at Lower Granite Dam, and from fish in the barges after transport, indicate that defenses against disease pathogens are significantly decreased after transportation (Schreck and Congleton 1994). In 1996, several assays were evaluated to determine their usefulness in evaluating the effects of stress on immune system function. Spring chinook juveniles (mid-Columbia River origin stocks) were held under crowded and uncrowded conditions (0.5 lb. fish/gal versus 0.05 lb. fish/gal density) and sampled at 3-, 7-, 14-, and 21-day intervals. Interferon (a factor involved in resisting viral diseases) was moderately lower than measured in the controls in one trial and was unaffected in a second trial. Oxidative burst activity by blood neutrophils (a factor involved in eliminating pathogens) was significantly depressed in the groups of crowded fish at all time periods.

From 1988 through 1992, researchers evaluated the prevalence (frequency of occurrence) and severity (degree of infection) of R. salmoninarum among fish in marked groups of Columbia River and Snake River hatchery spring chinook salmon, both before their release and during their seaward migration. During the study, the prevalence of infection decreased in six of the eight hatchery groups. The researchers attributed this decrease to changes in hatchery practices that reduced vertical and horizontal transmission of the infection (Maule et al. 1996).

The 1988 through 1992 studies also found that spring chinook from Snake River hatcheries had a higher prevalence of R. salmoninarum infection when they were sampled at dams than they did in the hatchery; no similar differences were noted in comparisons of Columbia River fish. The authors thought these differences between Snake River and Columbia River fish might have resulted from differing inriver conditions and the distances from the hatcheries to the dams. They assumed that after being released from a hatchery, the most severely infected fish would die first. Therefore, increases in the prevalence and severity of infection suggest that the infection progressed during the migration. The fact that increased prevalence and severity was detected in the Snake River but not in the Columbia River, suggests that the changes were caused by the river environment and not by the fishes' decreased disease resistance during smoltification. The authors conclude that differences in water temperature and longer migration times caused hatchery fish migrating in the Snake River to experience higher prevalence and severity of R. salmoninarum than did those in the Columbia River (Maule et al. 1996).

Live box studies suggest that under certain conditions, uninfected salmonid smolts can become infected with R. salmoninarum (presumably shed from infected smolts) during inriver migration or transportation. These studies, however, did not define the levels of waterborne R. salmoninarum necessary for the normal smolts to become infected, nor did they define the probability of transmitting the disease from smolts with known infection levels to uninfected smolts (Elliott and Pascho 1995). Studies have shown that in most years, the highest mean antigen levels were measured in fish sampled after 75% of the total migration had passed a given dam. It is of particular significance to note that when the largest numbers of fish were being collected for bypass or transportation, mean antigen levels were relatively low (Elliott et al. 1997).

The juvenile fish transportation program has established criteria that govern the holding and loading operations. Specifically, collected fish may not be held longer than two days, and there is a maximum loading density of 0.5 pounds of fish per gallon of water. This density is normally only attained during peak spring migration periods when the fish are being transported by barge. Juvenile fish transport by barge from Lower Granite Dam normally takes about 35 to 40 hours, depending on weather conditions. According to Maule et al. (1996), decreasing the loading densities in raceways and ponds enhances specific immune responses of juvenile salmon. Therefore, the combination of segregating juveniles and reducing the holding and loading densities may decrease the potential to transmit of R. salmoninarum and enhance the fishes' ability to resist the pathogen.

Conclusion: Studies suggest that under certain conditions, uninfected salmonid smolts can become infected with bacterial kidney disease (presumably from infected smolts) during inriver migration or transportation. In most years, the highest mean antigen levels have been measured in fish sampled after 75% of the total migration had passed a given dam. Mean antigen levels were relatively low when the largest numbers of fish were being collected for bypass or transportation.

Risk of Transportation to the Future Productivity of Listed Species

The comparison of the risks of transportation versus spill is not solely a matter of comparing expected changes in survival to adult returns at the collector dam of these two modes of passage through the hydroelectric system. Placing juvenile salmon into barges and moving them down the river may subject them to "natural selection" that formerly did not exist in the evolutionary history of the species. Juvenile emigrants that have genetically inherited behaviors and phenotypes that permit them to be readily guided by turbine intake screens may be more likely to be transported than juvenile emigrants not possessing these behaviors (Mundy et al. 1994; National Research Council 1996). Differences in the fish guiding efficiencies of various types of turbine intake screens within and among listed species are known to exist. The degree to which the selection process imposed by transportation, if one exists, changes the average population fitness (Kapuscinski and Lannan 1986) of the listed species is unknown, so it is a risk factor of unknown magnitude and sign.

The risk imposed on population fitness by taking juvenile salmon into transportation is not unlike the risks inherent in salmonid hatchery programs (Reisenbichler and McIntyre 1977; Waples 1995; Bottom 1996). In a hatchery program salmon are removed from the environment for a portion of their life cycle in order to provide higher overall survivals than would be possible in the natural environment. The same basic "hatchery rationale" supports the juvenile salmonid transportation program (Mighetto and Ebel 1994). The success of hatchery programs for many years was judged solely on the narrow basis of numerical responses; pounds of juveniles released and pounds or numbers of salmon and steelhead caught (Bottom 1996). Similarly, the benefits of the juvenile barge transportation program have been defined using only the ratio of barged to non-barged adult returns to the point of transportation. The ultimate test of transportation is whether or not it impacts individual fitness, and this can only be ascertained by work on the spawning grounds to determine reproductive success and production of offspring.

REFERENCES

Achord, S., G.M. Matthews, D.M. Marsh, B.P. Sandford, and D.J. Kamikawa. 1995a. Monitoring the migrations of wild Snake River spring and summer chinook smolts, 1992. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. U.S. Department of Energy, Bonneville Power Administration, Project 91-28, Contract DE-A179-91BP18800. 73 p.

Achord, S., J. Harmon, D. Marsh, B. Sandford, K. McIntyre, K. Thomas, N. Paasch, and G. Matthews. 1992. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1991. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Contract DACW68-84-H0034. 57 p. + appendices.

Bottom, D. L. 1996. Pacific salmon and their ecosystems: status and future options, pp. 569-597. In: R.J. Naiman and D. Stouder (eds). To till the water: a history of ideas in fisheries. Chapman Hall, New York.

Carlson, C.D., and G.M. Matthews. 1991. Fish Transportation Studies -- Priest Rapids Dam 1989. Annual Report. National Marine Fisheries Service, Coastal Zone and Estuarine Studies, Seattle, Washington. Grant County Public Utility District, Ephrata, Washington.

Carlson, C.D., and G.M. Matthews. 1992. Salmon transportation studies - Priest Rapids Dam, 1990. Annual Report. National Marine Fisheries Service, Coastal Zone and Estuarine Studies, Seattle, Washington. Grant County Public Utility District, Ephrata, Washington.

Chapman, D., C. Carlson, D. Weitkamp, G. Matthews, J. Stevenson, and M. Miller. 1997. Homing in sockeye and chinook salmon transported around part of their smolt migration route in the Columbia River. North American Journal of Fisheries Management 17:101-113.

Congleton J., W. LaVoie, C. Schreck, L. Davis, and M. Fitzpatrick, 1997a. Evaluation of the effects of descaling on short-term survival of migrating juvenile salmonids, year 2. Draft Annual Report, 1995. Idaho Cooperative Fish and Wildlife Research Unit, Boise, Idaho. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. 80p.

Congleton, J., W. LaVoie, C. Schreck, L. Davis, and D. Elliott. 1997b. Evaluation of the effects of descaling on short-term survival of migrating juvenile salmonids. Abstract. In: U.S. Army Corps of Engineers, 1997 Annual Research Review: Anadromous Fish Evaluation Program. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Ebel, W.J., D.L. Park, and R.C. Johnsen. 1973. Effects of transportation on survival and homing of Snake River chinook salmon and steelhead trout. Fisheries Bulletin 72:549-563.

Ebel, W.J. 1980. Transportation of chinook salmon, Oncorhynchus tshawytscha, and steelhead, Salmo gairdneri, smolts in the Columbia River and effects on adult returns. Fisheries Bulletin 78(2):491-505.

Elliott, D. and R. Pascho. 1993. Juvenile fish transportation: impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. Abstract. U.S. Fish and Wildlife Service, National Fisheries Research Center, Seattle, Washington.

Elliott, D. and R. Pascho. 1994a. Juvenile fish transportation: impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. Annual Report, 1992. U.S. Department of the Interior, National Biological Survey, Seattle, Washington. 79 p. + appendices.

Elliott, D. and R. Pascho. 1994b. Juvenile fish transportation: impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. Abstract. In U.S. Army Corps of Engineers, 1994 Annual Research Review: Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Elliott, D. and R. Pascho. 1995. Juvenile fish transportation: impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. U.S. Department of the Interior, National Biological Service, Seattle, Washington. Annual Report, 1993. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Contract No. E86920048. 59 p. + appendices.

Elliott, D., R. Pascho, and L. Jackson. 1997. Renibacterium salmoninarum in spring-summer chinook salmon smolts at dams on the Columbia and Snake Rivers. Journal of Aquatic Animal Health 9:114-126.

Graves, R., and C. Ross. 1998. Estimate of the proportion of Snake River fish that were transported at Lower Granite, Little Goose, and Lower Monumental Dams in 1995-1997, Draft Report. May 4, 1998. National Marine Fisheries Service, Hydropower Program, Portland, Oregon. 9 p. + tables

Harmon J., D. Kamikawa, B. Sandford, K. McIntyre, K. Thomas, N. Paasch, and G. Matthews. 1995. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1993. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Contract No. DACW68-84-H0034.

Harmon, J., B. Sandford, K. Thomas, N. Paasch, K. McIntyre and G. Matthews. 1993. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1992. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Independent Scientific Advisory Board (ISAB). 1998. Response to questions of the Implementation Team regarding juvenile salmon transportation in the 1998 season. ISAB Report 98-2. National Marine Fisheries Service, Hydropower Program, Portland, Oregon. 21 p.

Kapuscinski, A.R.D. and J.E. Lannan 1986. A conceptual genetic fitness model for fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 43:1606-1616.

Kelsey, D.A. 1997. Effects of steelhead trout (Oncorhynchus mykiss) on chinook salmon (O. tshawytscha) behavior and physiology. M.S. Thesis. Oregon State University. 52 p.

Marsh, D., J. Harmon, N. Paasch, K. Thomas, K. McIntyre, B. Sandford, and G. Matthews. 1997. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1996. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Contract No. E86960099. 26 p. + appendices.

Matthews, G. 1992. Potential of short-haul barging as a bypass release strategy. Issue Paper. National Marine Fisheries Services, Northwest Fisheries Science Center, Seattle, Washington. Issue Paper. 56 p.

Matthews, G.M., S. Achord, J.R. Harmon, O.W. Johnson, D.M. Marsh, B.P. Sanford, N.N. Paasch, K.W. McIntyre, and K.L. Thomas. 1992. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1990. Annual Report of Research. National Marine Fisheries Services, Northwest Fisheries Science Center, Seattle, Washington. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Contract No. DACW68-84-H-0034. 52 p. + appendix.

Matthews, G.M., D.L. Park, J.R. Harmon, C.S. McCutcheon and A.J. Novotny. 1987. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1986. National Marine Fisheries Services, Northwest Fisheries Science Center, Seattle, Washington. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Contract No. DACW68-84-H-0034. 35 p. + appendix.

Maule, A., D. Rondorf, J. Beeman, and P. Haner. 1996. Incidence of Renibacterium salmoninarum infections in juvenile hatchery spring chinook salmon in the Columbia and Snake Rivers. Journal of Aquatic Animal Health 8:37-46.

Mighetto, L. and W. J. Ebel. 1994. Saving the salmon: a history of the U.S. Army Corps of Engineers efforts to protect anadromous fish on the Columbia and Snake Rivers. Historical Research Associates, Seattle, Washington.

Mundy, P., D. Neeley, C. Steward, T. Quinn, B. Barton, R. Williams, D. Goodman, R. Whitney, M. Erho, and L. Botsford. 1994. Transportation of juvenile salmonids from hydroelectric projects in the Columbia River Basin; An independent peer review. Final Report. U.S. Fish and Wildlife Service, Portland, Oregon. 149 p.

Mundy, P. 1998. Comments on the draft biological opinion on operation of the Federal Columbia River Power System including the Smolt Monitoring Program and the Juvenile Fish Transportation Program during 1998 and Future Years. E-mail to L. Krasnow, National Marine Fisheries Service, Portland, Oregon. April 3, 1998.

National Research Council (NRC). 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C. 452 p

Olsen, E.O., R. Lindsay, and W. Burck. 1991. Summer steelhead in the Deschutes River, Oregon. Draft Report. Oregon Department of Fish and Wildlife, Research and Development Section, Corvallis, Oregon 81 p. + appendices.

Park, D.L. 1985. A review of smolt transportation to bypass dams on the Snake and Columbia Rivers. National Marine Fisheries Service, Northwest Fisheries Center, Seattle, Washington. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Contract No. DACW68-84-H-0034. 66 p.

Park, D.L., G.M. Matthews, J.R. Smith, T.E. Ruehle, J.R. Harmon, and S. Achord. 1984. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1983. National Marine Fisheries Service, Seattle, Washington. Annual Report. U.S. Army Corps of Engineers, Northwest Pacific Division, Portland, Oregon. Contract No. DACW68-78-C-0051. 39 p. + appendices.

Marmorek, D.R. and C.N. Peters (eds). 1998. Plan for Analyzing and Testing Hypotheses (PATH): Preliminary decision analysis report on Snake River spring/summer chinook. Draft Report. ESSA Technologies, LTD., Vancouver, B.C., Canada. 92 p. + appendices

Quinn, T.P. 1993. A review of homing and straying of wild and hatchery-produced salmon. Fisheries Resources 18:29-44.

Raymond, H.L. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer chinook salmon and steelhead in the Columbia River Basin. North American Journal of Fisheries Management 8:1-23.

Reisenbichler, R.R. and J.D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, Salmo gairdneri. Journal of the Fisheries Research Board of Canada 34:123-128.

Schiewe, M. 1998. Status of recent analyses of transportation of juvenile fish as a method to increase adult returns of spring/summer chinook salmon and steelhead to the Snake River Basin. Memorandum to W. Stelle (NMFS). March 23, 1998. National Marine Fisheries Service, Northwest Region, Seattle, Washington.

Schreck, C.B., L.E. Davis, and C. Seals. 1996. Evaluation of procedures for collection, bypass, and transportation of outmigrating salmonids. Objective 1: Migratory behavior and survival of yearling spring chinook salmon in the lower Columbia River and estuary. Draft Annual Report, 1996. Oregon Cooperative Fishery Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon. MPE-96-10.

Schreck, C., and L. Davis. 1997. Evaluation of migration and survival of juvenile salmonids following transportation. Abstract. In: U.S. Army Corps of Engineers, 1997 Annual Research Review: Anadromous Fish Evaluation Program. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Schreck, C. and J. Congleton. 1993. Evaluation of facilities for collection, bypass and transportation of outmigrating chinook salmon. Abstract. In: U.S. Army Corps of Engineers, 1993 Annual Research Review: Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Schreck, C. and J. Congleton. 1994. Evaluation of facilities for collection, bypass and transportation of outmigrating salmonids. Abstract. In: U.S. Army Corps of Engineers, 1994 Annual Research Review: Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Schreck, C., L. Davis, H. Lorz, and M. Beck. 1995. Evaluation of procedures for collection, bypass, and downstream passage of outmigrating salmonids. Draft Annual Report, 1995. Oregon Cooperative Fishery Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. LGR-96-XX-1. 13 p.

Schreck, C. L. Davis, and D. Kelsey. 1995. Evaluation of facilities for collection, bypass, and transportation of outmigrating chinook salmon. Draft Annual Report for 1995. Oregon Cooperative Fishery Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. JTF-92-XX-3. 41 p.

Schreck, C., L. Davis, D. Kelsey and P. Wood. 1994. Evaluation of facilities for collection, bypass, and transportation of outmigrating chinook salmon. Draft Annual Report for 1994. Oregon Cooperative Fishery Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. 51 p.

Schreck, C., S. Kaattari, L. Davis, C. Pearson, P. Wood, and J. Congleton. 1993a. Evaluation of facilities for collection, bypass, and transportation of outmigrating chinook salmon. Annual Report for 1992. Oregon Cooperative Fishery Research Unit, Department of Fisheries and Wildlife, Oregon State University and Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Boise, Idaho. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. 58 p.

Schreck, C., S. Kaattari, L. Davis, L. Burtis, P. Wood, and J. Congleton, T. Mosey, S. Rocklage, and B. Sun. 1993b. Evaluation of facilities for collection, bypass, and transportation of outmigrating chinook salmon. Draft Annual Report for 1993. Oregon Cooperative Fishery Research Unit, Department of Fisheries and Wildlife, Oregon State University and Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Boise, Idaho. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. 61 p.

Slatick, E., D.L. Park and W.J. Ebel. 1975. Further studies regarding effects of transportation on survival and homing on Snake River chinook salmon and steelhead trout. Fisheries Bulletin 73:925-931.

U.S. Army Corps of Engineers (Corps). 1985. Comprehensive report on juvenile salmonid transportation. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

U.S. Army Corps of Engineers (Corps). 1993. Endangered Species Act Section 10 permit application dated November 15, 1993; revised December 7, 1993.

U.S. Army Corps of Engineers (Corps). 1997. Juvenile Fish Transportation Program, 1996. Annual Report. U.S. Army Corps of Engineers, Walla District, Walla Walla, Washington. 109 p. + appendices.

Waples, R. S. 1995. Evolutionarily significant units and the conservation of biological diversity under the Endangered Species Act. Evolution and the aquatic ecosystem: defining unique units in population conservation. Journal American Fisheries Society 17:8-27.

Williams, R.N., P. Bisson, C.C. Coutant, D. Goodman, J. Lichatowich, W. Liss, L. McDonald, P. Mundy, B. Riddle, J.A. Stanford, and R.R. Whitney. 1998. Response to the questions of the Implementation Team regarding juvenile salmon transportation in the 1998 season. Independent Scientific Advisory Board (ISAB), Portland, Oregon. ISAB Report 98-2. U.S. Department of Energy, Northwest Power Planning Council, Portland, Oregon.

BASIS FOR NMFS DETERMINATIONS CONCERNING THE USE OF SPILL AS MITIGATION FOR OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM

May 1998

National Marine Fisheries Service
Northwest Region
7600 Sand Point Way NE
Seattle, Washington 98115

BACKGROUND

The Action Agencies proposed in their Biological Assessment to modify spill levels from those specified in 1995 RPA Measure 2. The NMFS undertook a comprehensive review of the new information regarding the effects of spill (Appendix C) including revised project-specific estimates of:

- Estimates of fish guidance efficiency (the proportion of juveniles approaching turbine intakes which are guided into bypasses);
- Total dissolved gas levels associated with spill levels at each project; and
- New spill efficiency estimates for some projects (i.e., the proportion of fish approaching a project that pass via the spillway, divided by the proportion of total flow that is spilled).

Extensive evidence exists, derived from several research projects conducted on the mainstem Snake and Columbia rivers, which supports spill as a safe route of dam passage for juvenile salmonids (relative to other routes of passage). In nearly every instance where spill survival and turbine survival have been compared, spill survival was significantly higher than turbine survival and was generally in the 97% to 100% range. These studies include Holmes (1952), Schoeneman et al. (1961), Long et al. (1973 through 1975), Raymond and Sims (1980), Sims and Ossiander (1981) and Ledgerwood et al. (1990).

The spill program prescribed in 1995 RPA Measure 2 was developed to meet a fish passage efficiency (FPE) target of 80% at all dams where transport was not possible or when transport was not a priority. The 80% level was chosen as a surrogate for a dam survival estimates which were not available for all species at all dams and would be difficult to manage on an inseason basis. Based on generally accepted passage route survivals, NMFS estimated that the 80% FPE goal would provide dam passage survival of at least 95% at each dam. In practice, however, spill necessary to reach the 80% FPE level (and therefore survival levels) could not be provided at some projects due to the requirement to control total dissolved gas (TDG) levels to within acceptable limits (Table A-1). The effects of spill and TDG on adult salmon were also of concern at many dams.

Table C-1. Estimate of FPE's [1] under the 1995 RPA Measure 2 assumptions re. FGE and spill caps (assuming 100 kcfs total flow at Lower Granite Dam and 240 kcfs at McNary Dam).				
Project	**FGE (%)** [2]	**80% FPE Spill (instantaneous kcfs)**	**120% TDG Spill Caps (kcfs)**	**Est. Actual FPE (%)**
LGR	50	87 (12 hr)	40	71
LGS	56	81 (12 hr)	35	67
LMN	55	82 (12 hr)	40	67
IHR	73	26 (24 hr)	25	80
MCN	70	118 (12 hr)	120	80
JDA	72	80 (12 hr)	50	77
TDA	43	156 (24 hr)	230	80
BON [3]	37 (P1) 44 (P2)	----	120	62

[1] FPE = (% of fish passing at night * ((night spill flow/total flow) * night spill efficiency rate))
+ (% of fish passing at night * (1-((night spill flow/total flow) * night spill efficiency rate))*FGE)
+ (% of fish passing during day * ((day spill flow/total flow) * day spill efficiency rate))
+ (% of fish passing during day * (1-((day spill flow/total flow) * day spill efficiency rate))*FGE)

[2] FGE estimates used in the 1995 RPA Measure 2 were for mixed run yearling chinook salmon.

[3] 80% FPE spill is not achievable at Bonneville Dam because of daytime limitations to spill to limit adult fallback as well as TDG.

In the three years since the 1995 FCRPS Biological Opinion was signed, NMFS' understanding of other factors affecting the spill program has changed. Whereas fish guidance efficiency levels have increased at some dams following the installation of extended-length screens, estimates for other dams have decreased because we have discovered weaknesses in past methods of measurement (Krasnow 1998 - Draft Report). For example, the estimate for FGE at McNary Dam has increased from an estimate of 70% in 1995 to current estimate of 81%. The increase is attributed to the installation of extended-length screens. On the other hand, the FGE estimate for John Day Dam dropped from 72% in 1995 to a current estimate of 57% because of a clearer understanding of biases inherent in former methods of testing FGE in the field (Krasnow 1998 - Draft Report). Another change in NMFS' estimation methodology involved adjusting mixed-run (i.e., hatchery plus wild) estimates of chinook FGE to reflect the guidance of hatchery chinook alone. This adjustment was performed because (1) some hatchery chinook are listed under the ESA and (2) data from FGE studies at some Snake River dams indicated that the guidance of hatchery chinook is lower than that of wild chinook (Krasnow 1998 - Draft Report). Guidance estimates for juvenile chinook will continue to be used to estimate spill parameters because their guidance efficiencies are lower than those of other listed fish. Therefore, they represent the most sensitive of the listed species. See Table C-2 for a comparison of past and present estimates of FGE for chinook.

Changes in the per-project flows, since 1995, at which spill has been capped by TDG limits are also shown in Table C-2. In most cases, the changes result from a better understanding of TDG levels after multiple seasons of monitoring in the river reaches below the spilling dams. In other cases, John Day and Ice Harbor Dams for example, the increase in spill resulted from the gas abatement measures required in 1995 RPA Measure 2 that have been implemented by the Action Agencies.

Table C-2. FGE's and spill caps estimated for the operations specified in 1995 RPA Measure 2 and for the 1998 season.

Project	1995 FGE [1] (%)	1998 FGE [2] (%)	1995-96 Spill Caps (kcfs@120% TDG) [3]	1998 Spill Caps (kcfs@120% TDG) [4]
LGR	50	73	40	45
LGS	56	76	35	60
LMN	55	47	50	40
IHR	73	60	25	75 [5]
MCN	70	81	120	150
JDA	72	57	50	180
TDA	43	39	230	230
BON	37 (P1)	32	120	120
	44 (P2)	37		

[1] FGE estimates used in 1995 RPA Measure 2, mixed run spring chinook.
[2] FGE estimates in Krasnow (1998 - Draft Report) for hatchery spring chinook.
[3] Spill caps presented by the Corps, RCC to the technical management team in April 1996, based on 1995 spill and spring 1996 spill tests.
[4] Spill caps estimates from Tanovan, personal communication, February 3, 1996, except John Day estimate from Dach, personal communication, February 20, 1998.
[5] This spill cap is an early estimate based on preseason tests. The actual cap may change somewhat based on inseason observations.

The region's understanding of the relationship between prescribed amounts of spill and total dissolved gas on the prevalence and severity of gas bubble disease in migrating salmonids has also changed. When the spill program was first proposed in 1995, there was some uncertainty about how the prescribed TDG levels would affect juvenile and adult migrants. Observations since that time have encompassed a range of flow and spill levels. The condition of uncontrolled spill during 1996 resulted in tailrace gas levels higher than 120% of saturation and was associated with an increase in the incidence of GBD symptoms. However, the severity of these symptoms remained low at all but the most extreme gas concentrations (Maule et al. 1997). Very few signs of GBD (i.e., less than one percent frequency of occurrence) were seen in migrating adult salmonids (regardless of FPE) when tailrace gas concentrations were held below the 120-percent level (Backman et al. 1997). Therefore, after three years of monitoring gas bubble disease, it now appears safe to say that gas levels in the 115% to 120% range do not threaten the survival of migrating salmonids (Maule et al. 1997).

Given that spill resulting in tailrace TDG concentrations of less than 120% do not threaten survival and that the direct survival of juvenile salmonids passing projects via spillways varies between 97% and 100%, NMFS reaffirms the determination in the 1995 FCRPS Biological Opinion that a spill program that does not result in concentrations higher than 120% TDG in the tailrace will increase the survival of migrating salmonids. The NMFS also believes that moving past the per-project FPE goals (stated in the 1995 RPA) to further increase juvenile survival would not violate the intent of the requests to the state water quality agencies for dissolved gas waivers. The intent of these waiver requests has always been to provide the best migrating conditions for juvenile salmonids while safeguarding other aquatic biota. This intent was recognized by the Oregon Department of Environmental Quality and Washington Department of Ecology during a meeting on May 8, 1996.

Preliminary smolt-to-adult return information from PIT-tagged fish released at or above Lower Granite Dam during 1994 and 1995 shows a pattern of lower returns for juveniles detected at multiple dams relative to fish that were transported, detected at only one dam, or not detected at all. This observation has led some fish and wildlife agencies to suggest that spill survival is higher than bypass survival. Just what percentage of undetected fish actually passed each dam via the spillway is unknown because some of these fish could have passed undetected through turbines and bypass facilities with no, or limited, PIT-tag detection capability (e.g., Bonneville and The Dalles Dams). However, because the study years included spill conditions, it is possible that most of the undetected fish passed through the spillways. This is particularly likely to have been the case during 1995 when high amounts of uncontrolled spill occurred 24 hours per day[16]. At this point, it is apparent that the survival of fish that went through the spillways under the conditions tested was higher than/was at least as high as that of fish which used other dam passage routes. And, it is reasonable to assume that dam passage survival would increase as more fish pass via the spillways (within project-specific limitations). The NMFS is currently evaluating these data and will provide a more detailed analysis when this evaluation is complete.

These same PIT-tag-based survival studies indicated that, in general, the survival of inriver migrants between Lower Granite and McNary Dams decreased late in the spring migration. Some have speculated that this decrease was due to increased total dissolved gas levels in this reach of the lower Snake and Columbia Rivers during May and early June. It is true that dissolved gas levels were high during this period. In fact, due to uncontrolled spill at Ice Harbor Dam, gas levels consistently reached 130% for long periods of time. It is, however, conjecture to say that these TDG levels caused the lower survival rates because there were other changing ambient conditions that could have affected survival (NMFS 1996, Annual Report to ODEQ). In any case, the TDG levels at Ice Harbor and other dams in this reach during the study years were much higher than the levels recommended in the NMFS spill program.

[16] Limited information on spill effectiveness indicates very high levels of effectiveness under large amounts of 24-hour spill.

The spill program developed in 1995 RPA Measure 2 contained two basic scenarios: 12- and 24-hour spill at FCRPS dams. One of these scenarios was prescribed for each dam depending on the diel pattern of juvenile passage that has been observed. Twenty-four-hour spill was prescribed for dams with a relatively flat diel distribution (i.e., where approximately the same number of juveniles pass during the day and night [such as Ice Harbor, The Dalles and Bonneville Dams]). Twelve-hour spill was prescribed at dams where nighttime juvenile passage was relatively high.[17] Unfortunately, most of the existing diel passage information has been obtained from investigations of powerhouse passage. In most cases, there is no information to indicate whether powerhouse diel passage patterns are similar to spillway passage patterns, particularly under conditions of 24-hour spill. It is therefore possible that the spill hours currently prescribed for each project do not provide the best juvenile passage conditions. This potential sampling error warrants further investigation of the timing of juvenile migrant passage via spillways.

Another reason that the 1995 RPA Measure 2 prescribed 12-hour spill at several dams was NMFS's concern about prolonged exposure of adults holding in the tailraces below these dams and at dams further downstream to high levels of TDG. However, the uncontrolled spill conditions that occurred during 1997 led to 24-hour spill at even those FCRPS projects where the 1995 RPA had prescribed 12-hour spill. The frequency of occurrence of GBD symptoms in sockeye and steelhead was much higher during 1997 than during 1995 or 1996. In studies at Bonneville Dam during 1997, up to 68% of the adult sockeye salmon and 16% of the adult steelhead examined under the highest TDG conditions (i.e., greater than 125%) exhibited signs of GBD. In comparison, the frequency of occurrence of GBD symptoms in adult chinook was less than one percent (relatively unchanged from the frequency of occurrence in either 1995 or 1996). The frequency of occurrence of GBD symptoms in adult chinook was also low at Lower Granite Dam, the only other site where adults were monitored consistently for GBD. These data indicate that adults of some species may be more susceptible to the effects of TDG than others. There may be a threshold TDG concentration and/or duration of exposure above which each species is susceptible to GBD.

Radio-tracking studies and adult counts at ladders indicate that adults tend to hold in tailrace areas and ladder systems at night and to move during the day. The vertical distribution of adults holding in the tailrace is largely unknown but existing data suggest that these fish are deep enough to receive at least some depth compensation for TDG (depth compensation equals approximately 10% TDG for each meter of depth). Once adults move into the ladder system, however, they rise in the water column (i.e., to within eight feet of the surface at most ladders), thereby increasing their susceptibility to GBD. Assuming that cycled spill was associated with periodic decreases in TDG concentrations, this type of operation may reduce this

---

[17] At this latter type of dam, most juveniles passed during the crepuscular period (i.e., higher numbers passed during the evening and early morning hours). For example, using the best diel passage data available, a 13-year data set from John Day Dam, 80% of the daily passage of spring chinook occurred between 1800 and 0600 hours at that project.

susceptibility. The ability to detect and understand changes in adult GBD symptoms relative to changes in TDG must be better understood before NMFS can recommend 24-hour spill and gas concentrations up to 120% of saturation at all dams.

NMFS DETERMINATION

Spill and Spill Related Recommendations

For the above-mentioned reasons, NMFS has reconsidered the spill volumes and scenarios contained in RPA Measure 2 of the 1995 FCRPS Biological Opinion. The NMFS has determined that it is reasonable to increase spill volumes beyond the 80%-FPE level at projects where this can be accomplished without exceeding the current TDG cap (or other project-specific limitations) during 1998 and future fish passage seasons. Table C-3 illustrates the differences in FPE and spill amounts (under a given flow scenario) between the recommended spill approach and an 80%-FPE spill approach. The estimated average FPE over the eight FCRPS dams is less than 80% under both strategies. However, the gas cap-limited spill approach results in a somewhat higher overall average FPE.

Table C-3. Estimates of fish passage efficiencies and spill volumes obtainable in 1998 under a 1995 FCRPS Biological Opinion-type spill program (i.e., 80% FPE limit) versus those obtainable with a gas cap-limited spill program (i.e., capped 120% TDG). Unless otherwise specified, 12-hour (i.e., 1800 to 0600) spill is prescribed. (Calculations assume 100 kcfs total flow at LGR and 240 kcfs total flow at MCN.)

Project	1995 BiOp (80% FPE) Approach			Gas Cap Limited Spill Approach		
	Spill Volume (kcfs)	**Instant Spill (%)**	**FPE[18]**	**Spill Volume (kcfs)**	**Instant Spill (%)**	**FPE[19]**
LGR	20 (12 hrs)	20	80	45 (12 hrs)	45	85
LGS	25 "	25	80	60 "	60	86
LMN	40 "	40	61	40 "	40	61
IHR	55 (night)	55	80	75 (night)	75	84
	45 (day)	45		45 (day)	45	
MCN	0	0	81	150 (12 hrs)	63	89
JDA	148 (12 hrs)	65	80	180[21] (12 hrs)	60	79
TDA[20]	156 (24 hrs)	64	79	156 (24 hrs)	64	79
BON	120 (night)	50	59	120 (night)	50	59
	75 (day)	31		75 (day)	31	
Ave. FPE			75			78

The specific spill volumes shown in Table C-3 must be viewed as approximate because the total dissolved gas levels measured at the monitoring site below each project, at a given spill level, can vary with such factors as forebay dissolved gas level, spill patterns, and water temperature changes. Also, there are many project-specific limitations on spill levels other than dissolved gas. These include adult passage, navigation, and research activities. These limitations are typically of short duration but they do reduce spill for fish passage to some degree. The NMFS recommendations for system spill and limits to spill duration for each project are discussed below:

[18] These FPE's are calculated with the same equation used in Table C-1, however, current FGE and TDG estimates are used. 80% FPE was used to cap spill.

[19] These FPE estimates are based on the same FGE and TDG data but the 120% gas cap and other project specific limitations were used to cap spill (limitations are described in the text below).

[20] Spill will be capped at 64% at this project, see project specific discussion in the text.

[21] The spill level at John Day Dam is capped at 180 kcfs for gas or 60% total flow due to tailrace conditions (see text below).

Planning Dates

The actual dates of spill and flow augmentation should be determined annually by the TMT based on inseason monitoring information. Planning dates are April 3 to June 20 and June 21 to August 31 for spring and summer, respectively, in the Snake River; April 10 to June 30 in the mid-Columbia River; and April 20 to June 30 and July 1 to August 31 for spring and summer, respectively, in the lower Columbia River.

Spill Trigger for Lower Snake River Collector Dams

Voluntary spill should occur at Lower Granite, Little Goose, and Lower Monumental Dams when the April 1 volume-of-runoff forecast indicates that seasonal average forecasted flows at Lower Granite Dam are projected to exceed 85 kcfs during the spring migration period (early April to June 20). The NMFS recognizes that, early in the season, voluntary spill may occur when river flows are substantially less than 85 kcfs. It is intended that voluntary spill be maintained to provide equitable spread-the-risk conditions throughout the migration season for the population as a whole.

System Wide Issues

Gas bubble disease monitoring of juvenile and adult salmonids should continue at all the current sites as defined in the NMFS 1998 Gas Bubble Disease Monitoring Plan. It is the determination of the NMFS Dissolved Gas Team (DGT) that the juvenile portion of the monitoring program has been reasonably well validated through the annual research and monitoring that has been conducted since 1994 (Mark Schneider, DGT cochair, pers. comm., March 2, 1998). However, two important research needs remain for the monitoring program: (1) a better understanding of the effects of extremely high near-field TDG levels on all species of salmonid and (2) verification of the adult salmon monitoring program.

Gas abatement studies should continue for all FCRPS dams including Chief Joseph and Grand Coulee Dam (including reducing high Boundary TDG levels). Even though there is no intentional fish passage in this reach, TDG generated by these two dams contributes to system TDG downstream and reduces the ability to provide fish-protective levels of spill at downstream dams.

Tailrace hydraulic conditions should be evaluated through general model studies to determine optimum spill patterns for minimizing the retention time of juveniles in spill basins and tailraces and for minimizing adverse conditions for adult passage at all dams where this has not already been accomplished. These evaluations have been completed for existing conditions at Bonneville, The Dalles and John Day Dams and have been partially completed for Ice Harbor Dam. Very little detailed information exists for McNary, Lower Monumental, Little Goose and Lower Granite Dams, particularly under the potential high spill levels called for in this Supplemental FCRPS Biological Opinion. Scale model studies will allow a timely assessment of tailrace conditions in a stepwise manner through a full range of spill and total flow levels and varied turbine unit operations. After implementation, the final patterns should be verified to the extent possible through field observations.

Information on spill efficiency (flow per fish) and effectiveness (percent of total project passage) is also needed at most FCRPS dams under a variety of spill and flow conditions. Limited information from radio-tagged juveniles passing several dams under very high flow conditions during 1996 and 1997 indicate that the spill scenarios which are effective for passing juvenile migrants may be different from those effective for passing adults. Information collected at John Day Dam in 1997 indicates that 24-hour spill may be much more effective than 12-hour spill in reducing residence time in the forebay (by allowing juvenile fish to pass as soon as they approach the dam). This study also indicated that, for some species, daytime spill may be more effective than nighttime spill. If spill is limited to 12 hours for adult concerns, these studies can help identify which 12 hours are best. It is likely that the John Day Dam example would hold true for other FCRPS dams.

Studies of spill effectiveness would also allow more accurate estimates of the smolt-to-adult return (SAR) rates of PIT-tagged fish released in the hydrosystem. Computation of SARs requires that the total number of smolts passing each project be estimated from rates of detection in the juvenile bypass system. This requires an accurate estimate of the percent of total project passage via the spillway versus the powerhouse. Spill effectiveness studies would provide the needed information.

Spillway survival estimates are needed for all dams under a variety of total flow and spill conditions. Currently, spill patterns and volume limitations are developed with physical models of the dams at the Corps' Waterways Experiment Station based on general and somewhat subjective estimates of the stilling basin retention time of juveniles, predation risk to juveniles, and adult-passage concerns. The current studies are set up to assess adult passage through the tailraces of FCRPS dams but very little effort has been made to estimate the effects these management options would have on juvenile survival.

Lower Granite Dam

The 100 kcfs spill trigger specified in the 1995 FCRPS Biological Opinion has been reduced to 85 kcfs. Spill operations for fish passage must also consider critical research data needs relating to the proposed evaluation of the prototype surface bypass/collector during spring 1998, and potentially, 1999. The federal parties have reached agreement on voluntary spill hours, spill volume, and powerhouse turbine operations during spring 1998. Specifically, during the spring SBC evaluation, spill will occur 24 hours per day with a minimum flow of 5.8 kcfs and a preferred maximum of 35 kcfs. Turbine unit operating priority will be units 1, 4,5,3 and 6. Unit 6 will not be operated unless necessary to control total dissolved gas saturation. In the absence of special operations for research, 12-hour nighttime spill to the

45-kcfs TDG cap will occur. The Action Agencies' preferred operation during the spring of 1998 is to maintain a constant powerhouse load (unit 1 @19.9 kcfs, and units 3,4,5 @15.5 kcfs).

Dissolved gas limitations - Depending on ambient forebay gas levels, spill to 120% TDG saturation will limit spillway flows to about 45 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity within one percent of peak efficiency is normally about 123 kcfs. However, in 1998, unit 2 will be out of operation and powerhouse capacity will be reached at flows of approximately 103 kcfs. Total river flows above this volume will cause involuntary spill. The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times. The Corps' Fish Passage Plan (FPP) specifies that units 1, 2, and 3, be given operating priority for fish passage during the daytime and the larger units (4, 5, and 6) be given priority at night.

Tailrace limitations - It may be necessary to limit spill in order to limit the occurrence of adverse hydraulic conditions in the tailrace. Poor hydraulic conditions resulting in large tailrace eddies can reduce adult passage efficiency and increase predation on juveniles passing through the spillway and bypass system. Based on radio-tracking studies with adult chinook, performed at Lower Granite Dam during 1996 and 1997, a spill level of 45 kcfs should not adversely affect adult passage (T. Bjornn fax to R. Kalamasz, S. Pettit, and J. Ceballos, dated April 4, 1998). It may be necessary to consider a lower limit to accommodate safety concerns when the project is direct-loading. The Corps has not conducted the specific modeling studies of tailrace spill patterns at Lower Granite that might identify other limits to spill. However, it is known that a large eddy forms below the powerhouse as spill levels increase. The formation and the size and shape of the eddy vary with spill level and turbine unit operations. Until modeling studies can be performed, the need for spill limitations to minimize this eddy will be assessed inseason by the TMT.

Little Goose Dam

Continue 12-hour nighttime spill at this project. PIT-tagged fish will be returned to the river after detection whereas other collected fish will be transported. Barge loading, which normally occurs in the late afternoon, can be hampered when two barges are in tow. A new secondary bypass system was installed for the 1997 season which releases bypassed smolts into positive downstream flow conditions.

Dissolved gas limitations - Depending on ambient forebay gas concentrations, spill to 120% TDG saturation will limit spillway flows to about 60 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity with unit operation within one percent of peak efficiency is approximately 123 kcfs. The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times. The FPP specifies that units 1, 2, and 3, be given operating priority for fish passage during the daytime and that the larger units (4, 5, and 6) be given priority at night.

Tailrace limitations - It may be necessary to limit spill in order to limit the occurrence of adverse hydraulic conditions in the tailrace. Poor hydraulic conditions resulting in large tailrace eddies can reduce adult passage efficiency and increase predation on juveniles passing through the spillway and bypass system. Based on radio-tracking studies with adult chinook, performed during 1997, a spill level of 60 kcfs should not adversely affect adult passage (C. Perry, Idaho Cooperative Fish and Wildlife Research Unit [ICFWRU] fax to J. Ceballos, NMFS, dated April 9, 1998). Specific modeling studies of tailrace spill patterns, for the purpose of identifying other limitations to spill at Little Goose, have not been conducted. However, inseason observations indicate that an eddy forms below the powerhouse at spill levels as low as 35%. The need for spill limitations to minimize this eddy will be assessed inseason by the TMT.

Lower Monumental Dam

Continue 12-hour nighttime spill at this project. PIT-tagged fish will be returned to the river after detection whereas other collected fish will be transported.

Dissolved gas limitations - Depending on ambient forebay gas levels, spill to the 120% TDG saturation will be limited to spillway flows of about 40 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity with unit operation within one percent of peak efficiency is approximately 123 kcfs. The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times. The FPP specifies that units 1, 2, and 3, be given operating priority for fish passage.

Tailrace limitations - Adverse hydraulic conditions (eddy at JBS outfall) during periods of high spill (spillway flows of 60 to 70 kcfs) have been observed at this project but have not yet been calibrated. Inseason observations indicate that spill levels of 50% or less may be necessary to minimize the eddy below the powerhouse. Due to the lack of specific data, the need for spill limitations to minimize this eddy will be assessed inseason by the TMT. Based on radio-tracking studies with adult chinook, performed during 1997, a spill level of 40 kcfs should not adversely affect adult passage (C. Perry, ICFWRU, fax to J. Ceballos, NMFS, dated April 9, 1998).

Navigation limitations - Barge loading for the juvenile transportation program normally occurs in the evening hours and has in the past been hampered by voluntary spill. A new mooring dolphin has been installed and is expected to allow spill to continue during barge loading in 1998 and future years. However, spill it may be necessary to temporarily reduce spill to accommodate the loading process.

Ice Harbor Dam

Hydroacoustic studies conducted by BioSonics, Inc., for the Corps have indicated a relatively flat diel passage distribution for juvenile migrants through this spillway. This passage pattern supports continued 24-hour spill this project.

Dissolved gas limitations - Spillway flows at Ice Harbor Dam will increase due to the additional spill deflectors installed during 1997. Spillway flows resulting in 120% TDG saturation (with eight of ten spillbays equipped with deflectors) is anticipated to be approximately 75 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity with unit operation within one percent of peak efficiency is approximately 94 kcfs. The BPA has specified 7.5 to 9.5 kcfs as the range of minimum powerhouse flows for system reliability. Because this range of minimum flows is related to the status of generation at other projects, it may not be necessary at all times. The FPP specifies that units 1,3, 4, and 2, be given operating priority for fish passage.

Tailrace limitations - It may be necessary to reduce spill levels as spill levels approach total river flow levels in order to maintain good hydraulic conditions in the tailrace. Poor hydraulic conditions resulting in large tailrace eddies can reduce adult passage efficiency and increase predation on juveniles passing through the spillway and bypass system. Preliminary modeling studies of tailrace spill patterns have been conducted for the purpose of optimizing spill patterns, however, specific spill volume limitations (other than for barge traffic) have not been determined. Past radio-tracking studies on adult passage indicate that a daytime spill cap of approximately 45 kcfs is necessary to maintain good adult passage (Turner et al. 1984). This daytime cap should be in effect from 0500 to 1800 hours. Preliminary data indicate that a spill level higher than 45 kcfs appears not to adversely impact adult passage (C. Perry, ICFWRU, fax to J. Ceballos, NMFS, dated April 9, 1998). However, no change is proposed for the 1998 season.

Navigation limitations - Under current conditions, spill flow presently causes problems for barge traffic exiting the navigation lock when river flows exceed 100 kcfs. The Corps has indicated that they will reduce spill as long as is necessary to pass navigation traffic. An alternative spill schedule for this purpose is included in the Corps' Fish Passage Plan. Temporary modifications to FPP spill patterns to improve navigation conditions will not be necessary once coffer-cell construction below the spillway is completed during the winter of 1998-99.

McNary Dam

Continue 12-hour nighttime spill and the secondary bypass of juvenile salmonids back to the river.

Dissolved gas limitations - Depending on ambient forebay gas levels, spillway flows at which the 120% TDG cap is reached may range between 120 and 160 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity with unit operation within one percent of peak efficiency is approximately 170 to 175 kcfs. This low capacity will cause involuntary spill to occur at normal spring flow levels. The BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability. The FPP specifies that units 1,2, and 3 be given operating priority for fish passage.

Tailrace limitations - A reduction in spill levels may be required at high spill percentages to maintain good hydraulic conditions for juvenile and adult passage in the tailrace. However, observations in the tailrace during high spillway flows have not indicated a problem. This may be due to the bathymetric and shoreline configuration of this tailrace which tends to force powerhouse flow in a northwesterly direction (i.e., toward the spillway side of the river) as it moves downstream. Nevertheless, because specific modeling of tailrace spill patterns for the purpose of identifying limitations to spillway flow under a variety of flow and unit operation conditions, the need for limitations should be assessed inseason by the TMT.

John Day Dam

Spill at John Day Dam will increase during 1998 due to completion of spillway flow deflectors during late 1997. Twenty-four hour spill should be investigated during 1999. High spillway effectiveness and high daytime passage were noted during 24-hour spill studies performed during 1997 (Memo for the Record from B. Dach, U.S. Army Corps of Engineers, February 3, 1998). Effectiveness was highest during the summer but daytime passage was much higher than expected during both spring and summer indicating a potential decrease in forebay residence time and subsequent predator exposure in this area.

Dissolved gas limitations - Nearfield TDG tests conducted during early 1998 indicate that spill volumes generating 120% TDG may be as high as 180 kcfs. Actual spill volumes will have to be determined in season because forebay gas level will probably affect this estimate.

Powerhouse flow limitations - The BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

Tailrace limitations - Spill volume at this project will be limited by tailrace conditions under high spill percentages and medium-to-low total river volume. In the gas cap-limited spill scenario illustrated in Table C-3 (above), 144 kcfs out of 240 kcfs total flow (i.e., 60%) was spilled. Based on modeling studies at the Corps' Waterways Experiment Station, under a variety of simulated flow levels, this percentage of spill is the maximum that does not cause the formation of a large eddy below the powerhouse, particularly in the vicinity of the juvenile outfall. These modeling studies also indicated that at least 25-percent spill was needed to create acceptable tailrace conditions below the spillway. Additional modeling studies, scheduled prior to the start of the 1998 spill season, will help refine these limits.

The Dalles Dam

No change is recommended to the current spill scenario at The Dalles Dam (other than those necessary for research) until the ongoing spill studies are completed. Research completed to date indicates that this spillway is not a benign passage route although it may be very efficient in passing fish. After one year of research, the survival study has indicated that, under very high spill levels (greater than 250 kcfs), the survival of the test fish (coho and subyearling chinook) was lower than anticipated (86% to 93%) (Dawley et al. 1998 - Draft Report). The survival of subyearling chinook was higher. These fish were passed through the system under lower spill levels, indicating a possible connection between spill volume and survival. Also, percentages of spill greater than about 40% send increasing amounts of water and fish over shallow rocky shelves just downstream of the spillway. Fish swept into these areas are more likely to fall victim to predation than fish that stay in the main channel. It is unknown if this predation reduces spill survival to something less than turbine survival. However, increasing spill above the 40% level is likely to move in the direction of increased harm. More information is needed before any management changes are warranted. Any spill management changes indicated by the results of survival and spill effectiveness studies at The Dalles Dam will be implemented in a timely manner through the Regional Forum process.

Dissolved gas limitation - Depending on ambient dissolved gas levels in the forebay, the 120% TDG cap can be as high as 230 kcfs at this project.

Powerhouse flow limitations - The BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

Tailrace limitations - Because of NMFS concern for juvenile survival through the spillway at high spill percentages and volumes, it is recommended that spill be limited to the 1995 FCRPS Biological Opinion level of 64% (rather than spilling to the TDG gas cap). The ongoing studies on passage survival and spill efficiency and effectiveness must be completed. In addition, and pending results of another year of survival studies, scoping should begin on methods to improve spillway survival at this dam (e.g., reconfigure the hydraulic characteristics of the stilling basin to reduce juvenile residence time).

Research limitations - Limited hydroacoustic data from 1996 studies indicate that 30% spill may be as effective at passing fish as the 64% required in 1995 RPA Measure 2 (BioSonics, Inc. 1997). Unfortunately, only three days of valid tests were completed at the 30% spill level. Additional tests during 1998 will help define this issue. Spill will be limited to 30% for approximately 50% of the 1998 fish passage season.

Bonneville Dam

No change is recommended to the Bonneville Dam spill scenario at this time. Spill, and therefore FPE, is limited by a relatively low TDG cap and by concerns for adult fallback during the daylight hours. These two issues should be the focus of continued research. Specifically, the Action Agencies should continue the ongoing project-specific gas abatement program for Bonneville Dam with focus on evaluating endbay flow deflectors and eliminating deep holes in the near tailrace. This work must also consider the effects that the implementation of gas abatement measures may have on passage and the safety of adult and juvenile salmonids. The ongoing study to reduce fallback of adults through the spillway should be expedited.

Dissolved gas limitation - Depending on ambient forebay dissolved gas levels, the 120% TDG cap is in the 100 to 150 kcfs range and averages about 120 kcfs at this project.

Powerhouse flow limitations - The BPA has specified a minimum powerhouse flow of 30 kcfs.

Tailrace limitations - The current spill pattern for Bonneville Dam was determined in modeling studies conducted in the early 1990's. These same studies indicated that a minimum spill level of 50 kcfs was necessary for adequate tailrace hydraulic conditions. There is no maximum spillway flow cap for fish passage. Because of the unique configuration of Bonneville Dam, flow from the spillway does not directly affect tailrace patterns below either of the two powerhouses.

Adult fallback limitation - Adult fallback through the spillway is known to be correlated to spill flow (Monan and Liscom 1975). The current spill cap for daylight hours is 75 kcfs.

REFERENCES

Backman, T.W.H., A.F. Evans, and M.A. Hawbecker. 1997. Symptoms of gas bubble trauma induced in salmon (Oncorhynchus spp.) by total dissolved gas supersaturation of the Snake and Columbia Rivers, USA. Columbia River Inter-tribal Fish Commission, Portland, Oregon. Report prepared for Bonneville Power Administration. Project No. 93-008-02, Tasks A.1 and J.1. 50 p.

BioSonics, Inc. 1997. Hydroacoustic evaluation and studies at The Dalles Dam, spring/summer 1996. Final Report prepared for U.S. Army Corps of Engineers, Portland District. BioSonics, Inc., Seattle, Washington.

Dawley, E., LG. Gilbreath, E.P. Nunnallee, and B.P. Sandford. 1998. Relative survival of juvenile salmon passing through the spillway of The Dalles Dam, 1997. Draft Report prepared for U.S. Army Corps of Engineers. Contract No. MIPR E96970020. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 46 p.

Holmes, H.B. 1952. Loss of salmon fingerlings in passing Bonneville Dam as determined by marking experiments. Unpublished manuscript. U.S. Fish and Wildlife Service, Vancouver, Washington. 62 p.

Krasnow, L.D. 1998. Fish guidance efficiency (FGE) estimates for juvenile salmonids at lower Snake and Columbia River dams, Draft Report. April 3, 1998. National Marine Fisheries Service, Hydropower Program, Portland, Oregon.

Ledgerwood, R.D., E.M. Dawley, L.G. Gilbreath, P.J. Bentley, B.P. Sandford, M.H. Schiewe. 1990. Relative survival of subyearling chinook salmon which have passed Bonneville Dam via the spillway or the Second Powerhouse turbines or bypass system in 1989, with comparisons to 1987 and 1988. Report prepared for U.S. Army Corps of Engineers. Contract No. E89850024 and E8690097. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 64 p.

Long, C.W. and F.J. Ossiander. 1973. Survival of coho salmon fingerlings passing through operating turbines with and without perforated bulkheads and of steelhead trout fingerlings passing through spillways with and without a flow deflector. Report prepared for U.S. Army Corps of Engineers. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Long, C.W. and F.J. Ossiander. 1974. Survival of coho salmon fingerlings passing through operating turbines with and without perforated bulkheads and of steelhead trout fingerlings passing through spillways with and without a flow deflector. Report prepared for U.S. Army Corps of Engineers. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Long, C.W., F.J. Ossiander, T.E. Ruehle, and G.M Matthews. 1975. Survival of coho salmon fingerlings passing through operating turbines with and without perforated bulkheads and of steelhead trout fingerlings passing through spillways with and without a flow deflector. Final Report prepared for U.S. Army Corps of Engineers. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Maule, A., J. Beeman, K.M. Hans, Matthew G. Mesa, P. Haner, and J.J. Warren. 1997. Gas bubble disease monitoring and research of juvenile salmonids. U.S. Geological Survey, Biological Resources Division. Prepared for Bonneville Power Administration, Portland, Oregon. Project No. 96-021, Contract No. 96AI93279. 104 p.

Monan, G.E. and K.L. Liscom. 1975. Radio-tracking studies to determine the effect of spillway deflectors and fallback on adult chinook salmon and steelhead trout at Bonneville Dam, 1974. Final Report prepared for U.S. Army Corps of Engineers. Contract No. DACW54-74-F-0122. National Marine Fisheries Service, Coastal Zone and Estuarine Studies, Seattle, Washington.

Raymond, H.L. and C.W. Sims. 1980. Assessment of smolt migration and passage enhancement studies for 1979. Report prepared for U.S. Army Corps of Engineers. Contract No. DACW68-78-C-0051 and DACW57-79-F-0411. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 48 p. + appendices.

Schoeneman, D.E., R.T. Pressey, C.O. Junge, Jr. 1961. Mortalities of downstream migrant salmon at McNary Dam. Transactions of the American Fisheries Society 90(1):58-72.

Sims, C.W. and F.J. Ossiander. 1981. Migrations of juvenile chinook salmon and steelhead trout in the Snake River from 1973 to 1979. Summary Report prepared for U.S. Army Corps of Engineers. Contract No. DACW 68-78-C-0038. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 31 p. + appendices.

Turner, A.R., J.R. Kuskie and K.E. Kostow. 1984. Evaluations of adult fish passage at Ice Harbor and Lower Monumental dams, 1982. U.S. Army Corps of Engineers, Portland District, Portland, Oregon. 66 p. + appendices.